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Methods of Estimating Heat Losses from Buildings

By CHARLES L. HUBBARD

[*Editor's Note.—The figures in Mr. Hubbard's table giving the heat losses for different materials and varying differences between the inside and outside temperatures present, in tabular form, the information contained in Mr. Reginald Pelham Bolton's interesting Heat Loss Chart, which was published as a supplement to the August, 1906, issue of* THE HEATING AND VENTILATING MAGAZINE. *In addition to some variations in the factors, Mr. Hubbard's table includes the figures for several additional forms of construction, which add much to its interest.*]

Authorities differ considerably in the factors and methods given for computing the heat losses from buildings. The following factors have been employed extensively in actual practice, and have been found to give satisfactory results when used with judgment. Table I gives the heat loss in thermal units for different materials and varying differences between the inside and outside temperatures:

The figures in Table I apply only to the most thorough construction. For the average well-built house the results should be increased about 10 per cent.; for fairly good construction, 30 per cent.

Table I also applies only to rooms having a southern exposure. For other exposures multiply by the factors given in Table II.

TABLE I

Material	Difference between inside and outside temperatures									
	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
8-inch Brick Wall	5	9	13	18	22	27	31	36	40	45
12-inch Brick Wall	4	7	10	13	16	20	23	26	30	33
16-inch Brick Wall	3	5	8	10	13	16	19	22	24	27
20-inch Brick Wall	2.8	4.5	7	9	11	14	16	18	20	23
24-inch Brick Wall	2.5	4	6	8	10	12	14	16	18	20
28-inch Brick Wall	2	3.5	5	7	9	11	13	14	16	18
32-inch Brick Wall	1.5	3	4.5	6	8	10	11	13	15	16
Single Window	12	24	36	49	60	73	85	98	110	122
Double Window	8	16	24	32	40	48	56	62	70	78
Single Skylight	11	21	31	42	52	63	73	84	94	104
Double Skylight	7	14	20	28	35	42	48	56	62	70
1-inch Wooden Door	4	8	12	16	20	24	28	32	36	40
2-inch Wooden Door	3	5	8	11	14	17	20	23	25	28
2-inch Solid Plaster Partition	6	12	18	24	30	36	42	48	54	60
3-inch Solid Plaster Partition	5	10	15	20	25	30	35	40	45	50
Concrete Floor on Brick Arch	2	4	6.5	9	11	13	15	18	20	22
Wood Floor on Brick Arch	1.5	3	4.5	6	7	9	10	12	13	15
Double Wood Floor	1	2	3	4	5	6	7	8	9	10
Wall of Ordinary Wooden Dwellings	3	5	8	10	13	16	19	22	24	27

For stone walls multiply the figures given for brick of the same thickness by 1.7. Where rooms have a cold attic above or cellar beneath, multiply the heat loss through walls and windows by 1.1.

TABLE II.

Exposure.	Factor.
N.	1.32
E.	1.12
S.	1.0
W.	1.20
N. E.	1.22
N. W.	1.26
S. E.	1.06
S. W.	1.10
N. E. S. W. or total exposure	1.16

In order to make the use of the table clear a number of examples are given illustrating its use.

Assuming an inside temperature of 70°, what will be the heat loss from a room having an exposed wall surface of 200 square feet and a glass surface of 50 square feet, when the outside temperature is zero? The wall is of brick, 16 inches in thickness, and has a southern exposure; the windows are single, and the construction is of the best, so that no account need be taken of leakage.

We find from Table I that the factor for a 16-inch brick wall with a difference in temperature of 70° is 19, and that for glass (single window) under the same conditions it is 85; therefore

Loss through walls =200×19=3800
Loss through windows = 50×85=4250

Total loss per hour, =8050 B.T.U.

In computing the heat loss through walls, only those exposed to the outside air are considered.

A room 15 feet square and 10 feet high has two exposed walls; one toward the north and the other toward the east. There are 4 windows, each 3 by 6 feet in size. The two in the north wall are double, while the other two are single. The walls are of brick, 20 inches in thickness, with an inside temperature of 70°, what will be the heat loss per hour when it is 10° below zero?

Total exposed surface =15×10×2=300
Glass surface = 3× 6×4= 72

Net wall surface = 228
Difference between inside and outside temperature 80°
Factor for 20-inch brick wall is 18
Factor for single window is 93
Factor for double window is 62

The heat losses are as follows:
Wall, 228×18=4104
Single windows, 36×93=3348
Double windows, 36×62=2232

9684 B.T.U.

As one side is toward the north and the other toward the west, the actual exposure is N. W. Looking in Table II, we find the correction factor for this exposure to be 1.26; therefore, the total heat loss is

9,684×1.26=12,201.84 B. T. U.

A dwelling house of fair wooden construction measures 160 feet around the outside; it has 2 stories each 8 feet in height; the windows are single and the glass surface amounts to one-fifth the total exposure; the attic and cellar are unwarmed. If 8,000 B. T. U. are utilized from each pound of coal burned in the furnace, how many pounds will be required per hour to maintain a temperature of 70° when it is 20° above zero outside.

Total exposure =160×16=2560
Glass surface =2560÷ 5= 512

Net wall =2048
Temperature difference =70—20=50°
Wall, 2048×13=26624
Glass, 512×60=30720

57344 B.T.U.

As the building is exposed on all sides, the factor of exposure will be 1.16.

The house has a cold attic and cellar and is of only fair construction, so we must increase the heat loss 10 per cent. for each of the first two conditions, and 20 per cent. for the last.

Making these corrections we have,

57,344 × 1.16 × 1.10 × 1.10 × 1.20
= 96,338 B. T. U.

If one pound of coal furnishes 8,000 B. T. U., then,

96,338÷8,000=12 pounds per hour, required to warm the building to 70° under the conditions stated.

For dwelling houses of the average construction the following simple method may be used. Multiply the total exposed surface by 45, which will give the heat loss in B. T. U. per hour for an inside temperature of 70° in zero weather.

The factor is obtained in the following manner: Assume the glass surface

to be one-sixth the total exposure, which is an average proportion. Then each square foot of exposed surface consists of one-sixth glass and five-sixths wall, and the heat loss for 70° difference in temperature would be as follows:

Wall,	5/6×19=15.8
Glass,	1/6×85=14.1
	29.9

Increasing this 20 per cent. for leakage, 16 per cent. for exposure, and 10 per cent. for cold ceilings, we have

$29.9 \times 1.20 \times 1.16 \times 1.10 = 45.$

The loss through floors is considered as being offset by including the kitchen walls of a dwelling house, which are warmed by the range and would not otherwise be included if computing the size of a furnace or boiler for heating.

If the heat loss is required for outside temperatures other than zero, multiply by 50 for 10° below, and by 40 for 10° above. This method is convenient for approximation in the case of dwelling houses, but the more exact method should be used for other types of buildings, and in all cases for computing the heating surface for separate rooms. When calculating the heat loss from isolated rooms, the cold inside walls as well as the outside must be considered.

The loss through a wall next to a cold attic or other unwarmed space may in general be taken as about two-thirds that of an outside wall.

One B. T. U. will raise the temperature of one cubic foot of air 55° at average temperatures and pressures, or will raise 55 cubic feet 1°. From this it is evident that the heat units required to raise the temperature of a given quantity of air through any number of degrees will be equal to the volume in cubic feet, multiplied by the rise of temperature in degrees, divided by 55. This may be expressed by the following equation:

$C \times T \div 55 = B.T.U.$, in which
C = cubic feet of air
T = rise in temperature in degrees.

To compute the heat loss for any given room or building, which is ventilated, first find the loss through walls and windows, and correct for exposure and leakage, then compute the amount required for ventilation as above and take the sum of the two. An inside temperature of 70° is always assumed unless otherwise stated.

Example—What quantity of heat will be required to warm 100,000 cubic feet of air to 70° for ventilating purposes when the outside temperature is 10° below zero?

$100{,}000 \times 80 \div 55 = 145{,}454$ B. T. U.

The factor 1/55 is approximately 1.1 for 60°, 1.3 for 70°, and 1.5 for 80°. Assuming a temperature of 70° for the entering air, we may multiply the air quantity supplied for ventilation by 1.1 for an outside temperature of 10° above zero, 1.3 for zero, and 1.5 for 10° below zero, which covers the conditions most commonly met with in practice.

Temperature Scales

By Thomas Tait

The three scales of temperature in use are:

1. Fahrenheit's, in which the point of water freezing is 32° and the boiling point of water is 212°. This is the scale in common use.

2. Centigrade, in which the point of water freezing is zero or 0°, and the boiling point 100°. This scale is principally used in France.

3. Reaumur's, zero or 0° being the freezing point of water and 80° its boiling point. This scale is used in several foreign countries.

To reduce Fahrenheit to Centigrade, subtract $32° \times 5 \div 9$.

To reduce Centigrade to Fahrenheit, multiply by $9 \div 5 + 32°$.

To reduce Fahrenheit to Reaumur, subtract $32° \times 4 \div 9$.

To reduce Reaumur to Fahrenheit, multiply by $9 \div 4 + 32°$.

To reduce Centigrade to Reaumur, subtract one-fifth.

To reduce Reaumur to Centigrade, add one-fourth.

The minus sign, thus —, when used for Centigrade or Reaumur, signifies below zero or freezing point.

Example: — 12° represents 12° below freezing point or zero.

Air Washing and Air Washers

A Discussion at the Recent Milwaukee Meeting of The American Society of Heating and Ventilating Engineers

PROF. J. H. KINEALY.—In considering the location of an air washer in a heating apparatus, the danger of the water in the washer becoming frozen is one of the important considerations and for that reason the air washer must be placed between the tempering coil and the fan. In many cases, it is advisable and, in some cases, absolutely necessary to have two tempering coils and place the air washer between the tempering coils; that is, we will have for the cold air fan a tempering coil to heat the air above the freezing point, then the air purifying apparatus, then another tempering coil and then the fan.

The apparatus that is installed today and usually called an air washer, is an air purifier. It not only washes the air and removes the dirt and dust, but it freshens and revivifies it, so that, in many cases, one can save money by using an air washer. Instead of taking the air from the outside, the air in the building can be recirculated and by being made made to pass through the air-purifying apparatus the peculiar smell that is found in badly-ventilated rooms will be removed and vitiated substances that come from the breath of human beings will be removed. Of course, it is not advisable to do that for too long a time.

We find that the hardest and most difficult particles of dirt to handle are soot, and the particles of soot, as they pass through the washer, will be covered with water which will be carried with the air. If these drops of water are allowed to enter the building, it means depositing dirt in the building as well as water, and the object of the eliminator is to remove this water and also to remove the water that has no dirt in it.

It is extremely difficult to determine how much dirt is taken out of the air. The only way that I know of aside from making a chemical test, is to run the apparatus and see whether or not the walls near the register are discolored. If they are discolored, the dirt is not being taken from the air. We find always that the dirt that sticks to the wall of the room into which we blow the air is made up of fine particles of soot. When dirt passes through the apparatus it may be due to the washer or it may be due to the eliminator. One may have a poor washer, yet a good eliminator should prevent the passage of dirt; or, on the other hand, one may have a poor eliminator and a good washer will prevent the passage of dirt.

As to what can be done with the washer in the way of cooling the air depends upon a great many conditions. There are times when the air can be cooled very much by being made to pass through the washer. There are other times when the air will be cooled but very little. On the other hand, if the humidity of the air, as it enters the washer, is high, then that air passing through the washer cannot evaporate any water and hence there will be very little cooling effect. If, on the contrary, the humidity of the air is comparatively low, then that air passing through the washer will evaporate water and the air will be cooled, because the cooling is done by the evaporation of the water. It is impossible to make a blanket guaranty as to the cooling of the air, for there are times when the air can be cooled a considerable number of degrees, and again when it can be cooled but very little. The same way with the humidity. It is impossible to make a blanket guaranty as to the humidity of the air leaving the eliminator for the reason that if the humidity of the air outside is 90 per cent. when it enters the washer, it will be not much less than 90 per cent. when it leaves the eliminator; that is, of course, assuming that we have an air purifying apparatus such as is ordinarily installed.

If we have refrigerating pipes, so that we can cool the air and precipitate the moisture, we can have any humidity we choose when the air leaves the eliminator and that is why, in the winter time, we can cover a wider ground with the air purifying apparatus, because we start then with the air at a low temperature and heat it up to the desired temperature and, although it may be saturated at the low temperature, we can regulate the humidity almost as we choose. But there are conditions that we encounter in the summer which without special cooling apparatus we cannot handle as well as we handle conditions in the winter.

VICE-PRESIDENT MACKAY. — If I recollect, Mr. Lewis advocated the elimination of a tempering coil in connection with a fan and he was asked if it were necessary to use an air washer, where he would put it. I think he said, in using it, that he would have to use a tempering coil.

PROF. KINEALY.—You may put in what I believe in Chicago is known as the Waters system; that is, all the heating pipes are on the outlet side of the fan, with the washer between the first bank of coils and the second. In winter you must heat the air above the freezing point, otherwise you will freeze the water in the washer. The water is used until it becomes foul. The peculiar thing is that in the summer time, on a hot day, we will put water in the tank of the washer, pass the air through the water and the water will get cooler. In other words, if the water, when we draw it from a hydrant and put it into the tank is, say, 78°, after the apparatus has been running a short time, an hour or so, all the water will be at a temperature of possibly 73°, 74°, or 75°, depending entirely upon the temperature of the outside air and the humidity of the air.

PROF. JOHN R. ALLEN.—I would like to ask Prof. Kinealy what is considered the proper resistance of the air washer to the air passing through it?

PROF. KINEALY.—As little as you can get along with. I have measured velocities of air passing through eliminators which varied all the way from 300 feet per minute up to 1,500 feet per minute. I advise you to get as near to 300 feet as you can. In a case where the velocity was 1,500, the average was 1,200, and that, together with the small inlet, cut down the capacity of the fans something like one-third; possibly even more.

PROF. ALLEN.—I have found the resistance a little high. Where we reduce the velocity to below 900 feet, we did not get proper elimination of the moisture. We had to obtain a fairly high velocity through the washer, with the result that, for best results, we had a resistance of about 0.3 of an inch of water, a rather higher resistance than we expected.

PROF. KINEALY.—That, of course, is a curious condition. Under a given set of conditions, with a certain amount of water pumped through the washer, if the air be made to pass quickly through the water, it takes up a small amount of water and the eliminator has almost no work to do. That is what happened with you. If the air is made to pass through the water at a low velocity, it takes up a large amount of water, and if the eliminator is not doing the work as it ought to, the water will not be taken out of the air. When you run the air slowly through the washer, cut down the amount of water and then you will not get water in the eliminator.

PROF. ALLEN.—Then you cut down the washer effect.

PROF. KINEALY.—Yes.

MR. THEODORE WEINSHANK.—All the air washers now on the market base their extraction of the entrained water upon either inertia or centrifugal force. If there is no inertia in the flow of the air and water you will not be able to do any elimination. Consequently there ought to be a limit in the positive or negative direction, and from my experience in the tests I have made, I have found there is a limit. I would never go over 400 feet per minute velocity, never less than 300 feet velocity, and between 300 and 400 feet there is a medium where elimination of entrained water can be obtained.

Concerning refrigeration, some years ago the Swift Company in Chicago undertook to ventilate their offices and it was done firstrate during the winter when we had an outside temperature below 32°. In that case we raised the temperature of the air by means of a tempering coil to about 50°, and we could control the humidity of the air very nicely. But in the summer time, when the outside temperature ran up to 75° and often to 80°, we found the humidity in the rooms was intolerable. They said, "let us experiment." They have refrigeration galore, so we piped the space between the eliminator and the suction of the fan with spiral galvanized 2-inch pipe, and when we started up our apparatus the engineer came up and said, "Gentlemen, cut it out, or I will have to shut down the plant. It takes all the elimination we have here, and then some." The engineer especially declared that commercially it was an impossibility.

PROF. ALLEN.—If it is intended to cool the air by means of an air washer, can it be done by cooling the water in the washer itself, by means of brine coils in the water tank?

MR. WEINSHANK. — In another washer we used the same air over and over again. We used a cake of ice 24 inches wide, 6 feet long and 8 inches deep and the water was about 16 inches deep in the tank. I put in the cake of ice, weighing about 100 pounds, and reduced the temperature of the water from 76° to 64° or 65°. The ice lasted just five minutes. Five minutes later the water was the same temperature as the air.

Cooling the air can be accomplished, as Professor Kinealy has said, if the air and water mix to such an extent as to have a total mixture, but before you can tell that you are reducing the temperature in the room you have to tell the temperature of the water, the temperature of the air and the humidity of the air.

MR. CHEW.—A paper was read before the society some years ago by the chief engineer of the Board of Control of Scranton, Pa., who cooled the auditorium of the Scranton High School building, I think, with several tons of ice on a hot commencement day and that paper is in the possession of the society.

MR. WEINSHANK.—I have had a little experience along that line at Evansville, Ind. At the opening of one of the theaters the manager wanted to show how cool a place he had, and in order to do that he asked me what I would suggest. It was about 85° in the shade. He had a fan and no tempering coil. There was an air duct leading from the outside to the fan, about 6 feet wide and 8 feet high. It was lined with galvanized iron. I put in that duct small baskets, made of wire, and filled those baskets with cracked ice and had the incoming air pass over the ice. He had a cool theater, but it kept four men handling ice. It lowered the temperature of that theater about 15°. We used 10 or 15 tons of ice, at least.

MR. CHEW.—The method described by Mr. Weinshank was similar to that adopted at the Scranton High School.

SECRETARY MACKAY.—In the Scranton building, the space cooled was about 100,000 cubic feet, the outside temperature was over 90° and they were able to maintain 70° during the commencement exercises, with about 5 tons of ice. They did not crack the ice. They used whole cakes. The question was raised at the time as to whether it would not cause too much humidity. The same method was used the following year and it was said to be satisfactory.

(For the benefit of those who may be interested in this system, the description of the cooling apparatus used in the Scranton High School building is presented on another page of this issue.)

MR. JAMES H. DAVIS.—I would like to ask Mr. Weinshank if he experimented in using water coils for the extraction of the humidity from the air after passing it through the washer?

MR. WEINSHANK.—In one case I circulated water through the coils in front of the fan; that is, after the extraction had taken place. After the air passed through the fan we cir-

culated cold water through the pipes and we found considerable moisture on the pipes, but, in that particular case, we allowed the water which entered the coils to run off into the sewer. The difference in temperature between the air and water was sufficient to cause some moisture to be deposited on the coils, but the drop in temperature in the air was very little, not over 4° or 5°.

MR. S. KAUFMAN.—I was present at a test where they took the air from behind the boiler at 105° and discharged it into the engine room to cool the engine room. They cooled the air 10°.

PROF. KINEALY.—As a matter of fact, it is a commercial possibility to cool the air as much as 5° under the conditions stated by Prof. Allen, but it is not a commercial possibility to undertake to cool it with the use of ice. Cool it by means of water from the hydrant. In St. Louis, the water from the hydrant is usually about 75° or 80°. If that water is put into an air washer and the right proportion of water to air is used, the temperature of the water will be reduced. As soon as the temperature of the water ceases to fall, empty that water and replace it with fresh water. It is not an expensive proposition at all. It is simply a matter of a little trouble.

Here is a thing that I am not yet able to explain, nor yet sure of, but I will state it to you. I think that better results will be obtained by heating the water slightly rather than by cooling it with ice, for we find, as I stated, that if the water be at a temperature of 78°, the water will be cooled when used in an air washer until it falls to a temperature of 73° or 74°. Then the water will stay at the one temperature. It appears that the cooling of the air is due to the evaporation of the water, and not to mere contact with the water.

I have studied the art very carefully. There is no literature on it. All the literature is in the Patent Office, and there have been a great many failures. On going back for years, one will find in the Patent Office records of attempts to purify the air, and it is from these that we gather our information, and they determine the lines along which we need not work.

Without touching at all upon any patents, I can briefly speak of the washer and the eliminator. There are three methods disclosed in the art for washing the air. In the first method the air is made to pass through one or more sheets of water. The sheet is made as complete as possible. In the second method, the water is injected in the air in the form of a fine mist or spray and flows in nearly the same direction as the air. In the third method, the water is made to pass at right angles to the direction of flow of the air, and the water is made to assume, as nearly as possible, the same condition as rain in outside air and with this rain there is a fine mist or spray.

As regards the eliminators, we have the eliminator which Mr. Kauffman has described. That is a modification of the old-style centrifugal eliminator, based upon the idea that, water being heavier than air, if the air and water be made to rotate, the water will separate and pass to the outer circumference of the rotating vessel, exactly as in a dryer in a laundry. There the wet clothes are put in a vessel and the vessel is rotated at a high velocity and the water, due to centrifugal force, passes to the outer side. That is one method. The other is where the air is deflected from side to side horizontally and the water is eliminated largely by contact with the surfaces along which the air moves and rubs. Still another is where the air is made to deflect alternately upward and downward, the object being to make the air go upward, and as the direction is suddenly changed from downward to upward, the heavier particles of water will fall down and the air will go up. Then we have still another method, where the air, due to the shape of the eliminator, is set into motion in whirling eddies at different points, in that way combining the centrifugal action and at the same time causing the air to rub

along the surfaces, the object being to get a combination of centrifugal action and rubbing action.

PROF. ALLEN.—Professor Kinealy spoke of the fine soot passing through the eliminator. We have made some experiments on the matter of washing the soot out of smoke, which looks attractive on the face of it. We had peculiar results. We could wash out all the heavy particles and we could wash out an immense quantity of carbon from the smoke by means of an air washer introduced into the breeching of a boiler, but the top of the chimney looked the same when we got through. It is really the fine particles of smoke that make the appearance of smoke in the air, not the heavy particles and what you get in the washer are excessive quantities of heavy particles.

MR. P. J. DOUGHERTY.—Prof. Kinealy recommends circulating the air in the building over and over again. The washer will, no doubt, eliminate the organic matter and the vapor, but will it eliminate the carbon dioxide, and how would you account for the decrease and the deficiency of oxygen? From that standpoint, would it be advisable to continue circulating the same air in the building, on account of the increase in carbon dioxide and decrease in oxygen?

PROF. KINEALY.—First of all, we know that the slight increase in carbon dioxide is not deleterious; the change or increase from 6 parts of carbon dioxide in 10,000 parts of air to 10 or 20 parts is not deleterious, but we use that only as a measure to determine how vitiated the air is. The things that are really deleterious are the epithelium scales that come from the throat as we breathe and the organic matter carried with the moisture. If we wash that out of the air, substituting for this moisture other moisture, we purify and revivify it, but we do not take out the carbon dioxide. That is why I said it is not advisable to continue this circulation of old air too long.

MR. WM. G. SNOW.—In the use of air washers, is any special provision made as to the source of air supply? Do you take it from the sidewalk level, in the case of city buildings, or from the tops of buildings, as has been the custom? I have in mind a bank building in Boston where an air washer was installed and the air was taken from the level of the sidewalk and that avoided the necessity of running a vertical intake flue, making a great saving in the cost of the installation.

I have had a little experience in taking air from the tops of buildings and, while theoretically that may be the source of the purest supply, yet, in several cases, I have had trouble from pulling smoke into the building when the wind was from a certain direction, or offending chimneys had been belching forth black smoke. Again, by having the intake near the street level, we have the street dust to contend with.

MR. WEINSHANK.—If the air washer is properly constructed and designed and proper velocities are used, it is possible and practicable to eliminate nearly 100 per cent. of the dirt, like dust, soot, etc., and it does not make any difference whether you take the air from the top or the sidewalk level.

For cooling purposes and for the control of the humidity, I am somewhat skeptical as to the value of air washers, but as far as air purifying is concerned, I will say positively, and I have had an experience of about seven years, that the time is coming, and in the near future that, whenever a fan is installed, the air washer will be installed along with the heating and tempering coils. They will be an absolute necessity, if the blast system is going to be adopted universally for ventilating purposes. The blast system has been a failure in a number of places for that very cause, that it was introducing too much dirt into the building.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Proceedings of Semi-Annual (Mid-Summer) Meeting, Milwaukee, Wis., July 18-19, 1907

(Concluded)

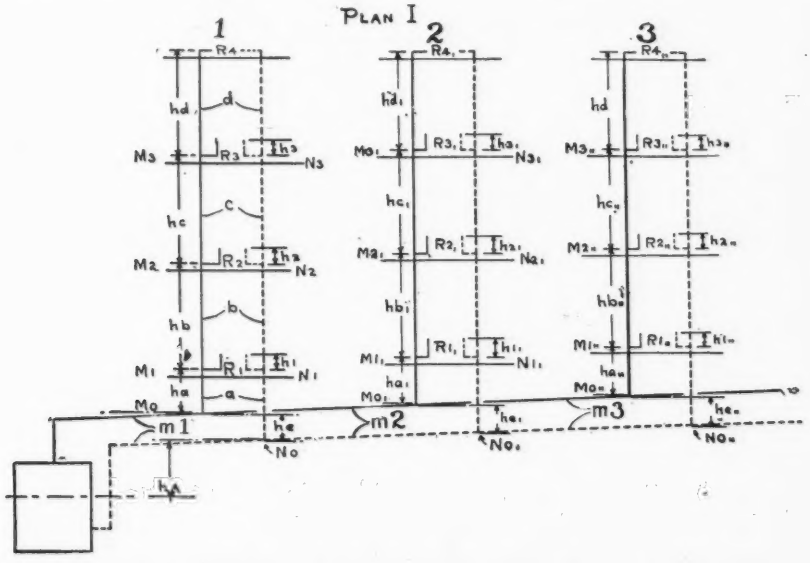
*Formula for Pipe Sizes in Hot Water Heating**

By Oliver H. Schlemmer

The subject of pipe sizes in hot-water heating is one that has never been given much attention outside of the discussions along general lines. At present pipe sizes are calculated more or less by rules of thumb, and in some cases by the additional use of tables based on the theoretical velocities, friction not considered.

Radiation is figured out quite closely at the present time as a result of the numberless experiments performed; yet, considering the calculation, as applied in present practice, is so much in error as to result in some radiators in a system having a much higher and others (in the same system) a much lower average temperature than was actually assumed in figuring the radiation. Still further, in two-pipe systems, the troubles of short circuits and as a consequence no circulation in distant radiators, has been experienced by every heating engineer and contractor.

Valves have been inserted in many cases in radiator and riser connections and in the individual parts of vertical risers for the purpose of throttling where necessary to overcome short circuits. Experimenting in trying to overcome these short circuits has been not only a large expense to the contractor, but final dissatisfaction.



tion of pipe sizes as a problem in hydraulics, it can be readily seen, that though the radiation may be considered exact for practical purposes, the pipe sizes are not. It may be still further stated that the pipe size calcula-

*Paper read at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Milwaukee, Wis., July 18-19, 1907.

As a result of this uncertainty in determining pipe sizes, the writer some four years ago decided to go into the problem of pipe sizes and try to obtain a formula which could be applied practically. The results of this work are given in this paper. The formula applies to all systems, it being merely a matter of making up the equations in such a manner as to conform with the principle laid down. Surprising differences in sizes of pipe between the present as used and those worked out by the formula will be noted.

THE FORMULA AS WORKED OUT THEORETICALLY

The formula will be first worked out theoretically by means of a two-pipe system, referring to Plan I and then a system worked out as per Plan II. Referring to Plan I, the following symbols are used:

γ_1 = weight of a cubic foot of water at temperature in feed pipe.

γ_2 = weight of a cubic foot of water at temperature in return pipe.

ture of water passing through a radiator; *i.e.*, in the system.

R = square feet of radiation.

Q = volume of water in cu. ft. per second flowing through the pipe.

v = velocity of water in feet per second through the pipe.

$$\frac{\gamma_2+\gamma_1}{2}=C_1$$

$$\gamma_2-\gamma_1=C_3$$

$$\sqrt{\frac{4H'}{\pi C_1 T}}=C_4$$

l = length in feet of pipe, including equivalent length for elbows, valves, etc.

d = diameter in feet.

$$\frac{4fC_1}{2g}=C_2.$$

$$\sqrt{R}=C.$$

The numerals in Plan I refer to the individual parts of risers, mains and connections. Then

$$Q_4=\frac{\pi d_4^2 v_4}{4}=\frac{H'R_4}{C_1T} \qquad \therefore d_4=\sqrt{\frac{4H'R_4}{\pi C_1 T v_4}}$$

$$Q_3=\frac{\pi d_3^2 v_3}{4}=\frac{H'R_3}{C_1T} \qquad \therefore d_3=\sqrt{\frac{4H'R_3}{\pi C_1 T v_3}}$$

$$Q_2=\frac{\pi d_2^2 v_2}{4}=\frac{H'R_2}{C_1T} \qquad \therefore d_2=\sqrt{\frac{4H'R_2}{\pi C_1 T v_2}}$$

$$Q_c=\frac{\pi d_c^2 v_c}{4}=\frac{H'(R_4+R_3)}{C_1T} \qquad \therefore d_c=\sqrt{\frac{4H'(R_4+R_3)}{\pi C_1 T v_c}}=\frac{C_4C_c}{v_c^{\frac{1}{2}}}$$

$$Q_x \text{ (in general)}=\frac{\pi d_x^2 v_x}{4}=\frac{H'(R_1+\ldots R_x)}{C_1T}$$

$$\therefore d_x=\sqrt{\frac{4H'(R_1\ldots R_x)}{\pi C_1 T v_x}}=\frac{C_4C_x}{v_x^{\frac{1}{2}}}$$

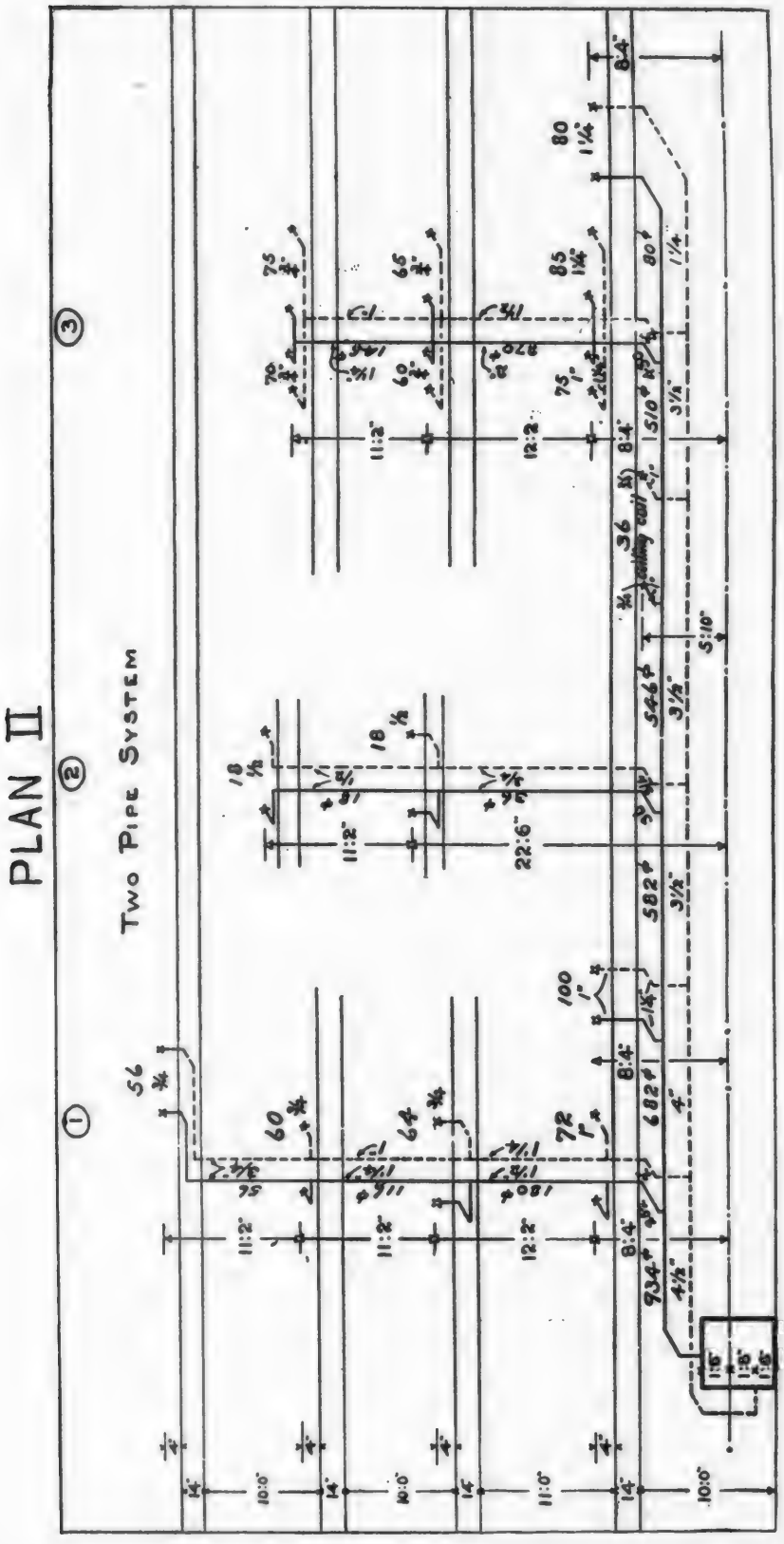
f = coefficient of friction for water.

H = heat units passing off per average sq. ft. of radiation per hour.

H′ = heat units passing off per average sq. ft. of radiation per second = H ÷ 3,600.

T = difference in temperature between the feed and the return water or the drop of temperature of water passing through a radiator; *i.e.*, in the system.

It is assumed that the temperature of the water in the feed pipes and that in the return pipes are the same throughout the system. This is not true in practice when the pipes are not covered and when the piping extends a considerable distance from the boiler. Corrections in the radiation can, however, be made for this addi-


PLAN II
TWO PIPE SYSTEM
1
2
3

tional loss in temperature after the formula has been applied and the pipe sizes obtained. It is also assumed that the density of the water throughout is $\gamma_2+\gamma_1\div 2$. It is further assumed that the diameters of corresponding feed and return pipes are the same.

RETURN PIPE CONSIDERED AS A PUMP

The theory is based upon the fact that each return pipe can be considered as a pump with the actuating head equal to the vertical height of the pipe multiplied into the difference in weight of corresponding feed and return water due to the drop in temperature T; that this force is transmitted through the system and causes the water to circulate. When the feed and return tappings are at the bottom it is assumed that the vertical height of the radiator has no effect on the circulation in the system but simply locally in the radiator itself.

Consider the part d of Riser No. 1 from the third to the fourth floor. The actuating head in this part of the riser is the vertical distance between the center of the tee connecting to radiator R_3 and the center of tapping in radiator R_4 (equal to h_d) multiplied into the difference of weight per cubic feet of water in the feed and in the return (equal $\gamma_2-\gamma_1$), resulting in $h_d(\gamma_2-\gamma_1)$. Again, since the flow of water in the system is to be considered uniform, if follows that the difference in actuating force per unit area between points M_3 (the point where the water divides to pass into radiators SR_3 and R_4) and N_3 (the point where the water from radiators R_3 and R_4 join) must equal the friction loss per unit area in the connection to either radiator minus any "actuating head" per unit area in the respective connection. It will be readily seen that this equation is merely a balancing of forces, the flow of water being assumed uniform.

Now the force required to overcome friction is represented by the well-known formula $4f\gamma lv^2\div 2gd$ where γ is equal to the density of the water; l = length of pipe in feet; v = velocity in feet per second; f = coefficient of friction; $g=32.2$; d = diameter of the pipe in feet. In this problem $\gamma=C_1$. From the equation of forces, as above explained, follows the following fundamental principle; *i.e.*, that the friction head minus the "actuating" head in connections common to each other must be equal. Hence we obtain the following equations where h equals the vertical distance between two tees in a riser or between tee and radiator tapping, as the case may be (*i.e.*, in general the vertical height of the actuating head considered).

For Riser 1 we have

$$\text{At points } M_3, N_3, (1)\ C_2\frac{l_3v_3^2}{d_3} - C_3h_3 = C_2\frac{(l_d+l_4)v_d^2}{d_d} - C_3h_d$$

$$\text{At points } M_2, N_2, (2)\ C_2\frac{l_2v_2^2}{d_2} - C_3h_2 = C_2\frac{l_cv_c^2}{d_c} + C_2\frac{l_3v_3^2}{d_3} - C_3h_c - C_3h_3$$

$$\text{At points } M_1, N_1, (3)\ C_2\frac{l_1v_1^2}{d_1} - C_3h_1 = C_2\frac{l_2v_2^2}{d_2} + C_2\frac{l_bv_b^2}{d_b} - C_3h_b - C_3h_2$$

$$\text{At points } M_0, N_0, (4)\ C_3h_A - \gamma_1h_e - C_2\frac{l_{m1}v_{m1}^2}{d_{m1}} = C_2\frac{l_av_a^2}{d_a} + C_2\frac{l_1v_1^2}{d_1} - C_3h_a - \gamma_2h_e - C_2h_1$$

Transposing in (4) and substituting for d its value in terms of v we have

$$(5)\ \frac{C_3}{C_2}(h_A+h_e+h_a+h_1) = \frac{l_av_a^{\frac{5}{2}}}{C_4C_a} + \frac{l_1v_1^{\frac{5}{2}}}{C_4C_1} + \frac{l_{m1}v_{m1}^{\frac{5}{2}}}{C_4C_{m1}}$$

But $(h_A+h_e+h_a+h_1)$ equals the height from the middle line of the boiler water height to the center of tapping of radiator R_1. Hence calling this h'_1.

$$(6)\quad \frac{C_4C_3}{C_2}\,h'_1=\frac{l_a}{C_a}v_a^{\frac{5}{2}}+\frac{l_1}{C_1}v_1^{\frac{5}{2}}+\frac{l_{m1}}{C_{m1}}v_{m1}^{\frac{5}{2}}$$

In the same manner we obtain from Riser 2

$$(7)\quad \frac{C_4C_3}{C_2}\,h'=\frac{l'_a}{C'_a}v'_a{}^{\frac{5}{2}}+\frac{l'_1}{C'_1}v_1^{\frac{5}{2}}+\frac{l_{m1}}{C_{m1}}v_{m1}^{\frac{5}{2}}+\frac{l_{m2}}{C_{m2}}v_{m2}^{\frac{5}{2}}$$

and in the same manner a similar equation for Riser 3, etc. It will be seen that there will be as many equations as are risers (connections off mains). But there are more variables (velocities) than are required to solve the problem which means that the work could be laid out in an almost infinite number of ways. It is uniformity as far as possible in the velocities that we desire to obtain as producing the least eddy friction as a result of large changes in velocities at reducing tees.

Therefore, since there are no other conditions to be observed, we will make the velocity in part *a* of Riser 1 equal to that in connection R_1 and likewise in Riser 2, etc., as also the velocities in different parts of the mains (1), (2), etc., equal throughout. This will make Equations 6 and 7 as follows:

$$(8)\quad \frac{C_4C_3}{C_2}\,h'_1=\left(\frac{l_a}{C_a}+\frac{l_1}{C_1}\right)v_1^{\frac{5}{2}}+\frac{l_{m1}}{C_{m1}}v_{m1}^{\frac{5}{2}}$$

$$(9)\quad \frac{C_4C_3}{C_2}\,h'=\left(\frac{l'_a}{C'_a}+\frac{l'_1}{C'_1}\right)v_1^{\frac{5}{2}}+\left(\frac{l_{m1}}{C_{m1}}+\frac{l_{m2}}{C_{m2}}\right)v_{m1}^{\frac{5}{2}}$$

and in general

$$(10)\quad \frac{C_4C_3}{C_2}\,h=\Sigma\left(\frac{l_r}{C_r}\right)v_r^{\frac{5}{2}}+\Sigma\left(\frac{l_M}{C_M}\right)v_m^{\frac{5}{2}}$$

Where *r* refers to riser and *M* to main, Σ = summation. Equation 10 is the equation by means of which any system of hot-water heating pipe sizes can be solved. There will be as many similar equations as there are connections off mains. The value of $\frac{C_3C_4}{C_2}$ depends, as seen before, on T, difference of temperature between feed and return water and also on H, the heat units given off per square foot per hour.

From the series of equations similar to the above general equation it will be seen that there is one more variable than necessary to solve the equations. As a consequence, any velocity for the mains could be assumed such as would positively satisfy all equations. It is desirable to obtain the largest possible velocity so as to obtain small diameters of piping. This can be obtained by inspection of the various equations similar to equation 10, assuming the riser velocities equal to the main velocity and such an equation found as will give the proper velocity and still maintain the equations positive. Having found $v_M^{\frac{5}{2}}$, in this way it is an easy matter by means of the slide rule to find $v_r^{\frac{5}{2}}$ and then from fifth root tables $v_r^{\frac{1}{2}}$. $d_r = C_4C_r \div v_r^{\frac{1}{2}}$ as seen before. From this, knowing $v_r^{\frac{1}{2}}$ d_r can be found.

In like manner the diameters of the mains can be fixed. To obtain the diameters for parts *b*, *c* and *d*, also for the connections in R_2, R_3 and R_4 in Riser I, after having solved the main velocities and velocities in parts *a*, of all riser connections, Equations 1, 2 and 3 are used, simply rearranging them as in solving Equation 10 with the assumption which can be made that velocity in part *b* equals velocity in radiator connection R_2, that in part *c* equals that in radiator connection R_3, and that in part *d* equals that in R_4. It is to be noted, however, that velocities *a*, *b*, *c* and *d* will all be

different from one another. This, then, gives for equation

$$(3)\quad (11)\quad \left(\frac{l_2}{C_2}+\frac{l_b}{C_b}\right)v_2^{\frac{5}{2}}=\left(\frac{l_1}{C_1}\right)v_1^{\frac{5}{2}}+\frac{C_4C_3}{C_2}(h_b+h_2-h_1)$$

$$(2)\quad (12)\quad \left(\frac{l_3}{C_3}+\frac{l_c}{C_c}\right)v_3^{\frac{5}{2}}=\left(\frac{l_2}{C_2}\right)v_2^{\frac{5}{2}}+\frac{C_4C_3}{C_2}(h_c+h_3-h_2)$$

$$(1)\quad (13)\quad \left(\frac{l_d+l_4}{C_4}\right)v_4^{\frac{5}{2}}=\left(\frac{l_3}{C_3}\right)v_3^{\frac{5}{2}}+\frac{C_4C_3}{C_2}(h_d-h_3)$$

Taking Equation 11 it is seen that $v_1^{\frac{5}{2}}$ has been solved by Equation 10. There being only one unknown quantity $v_2^{\frac{5}{2}}$, this can be easily solved and then Equations 12 and 13 and then d as in solving Equation 10. Equations 11, 12 and 13 show very nicely, as did Equation 10, that the friction losses must balance the actuating heads due to a difference of temperature T in the system.

By constant use of this formula it will be found that different assumptions as to which parts shall have equal velocities can be made. The writer has sometimes assumed the velocities in the entire individual riser as equal, making the velocities in the connections different. This assumption, however, may give negative results for some of the lower connections. It will be seen that by the method shown in Equations 11, 12 and 13 the right-hand side of the equations will always be positive. This method is therefore preferred.

The writer uses Equation 10 in the form

$$(14)\quad \Sigma\left(\frac{l_r}{C_r}\right)v_r^{\frac{5}{2}}=\frac{C'_4C_3}{C_2}\sqrt{Hh}-\Sigma\left(\frac{l_M}{C_M}\right)v_M^{\frac{5}{2}}$$

$$\text{where } C'_4=\sqrt{\frac{4}{\pi C_1 T\times 3{,}600}}=\frac{C_4}{\sqrt{H}}$$

This formula will be applied to a two-pipe system. Before doing this, however, explanation of the various coefficients will be made.

EXPLANATION OF COEFFICIENTS

It is a difficult matter to determine just what value of f, the coefficient of friction, to use, considering the couplings and tees which make up a part of the piping. As the writer has found that the velocity in the mains averages about 0.25 feet per second and in the risers and connections from 0.25 to 0.64 feet per second, he decided to take $f=0.007$ for a velocity of 0.3 feet per second for an 8-inch pipe as per table by Fanning (D'Arcy's formula) and make the corrections in l for larger or smaller sized pipe as per this table before applying the l to the formula. The proportions of l to be added or substracted are given in Table A. Referring to general equation 11, it will be seen that any error in selecting H or f will not effect the system as far as proper proportion is concerned. The velocities are all effected, but in a proportionate manner. Table B gives the values of C_3, C'_4, and $C'_4C_3 \div C_2$ for different differences of temperature T.

The friction of elbows is found by use of Prof. L. E. Bellinger's formula (See Church's Mechanics, p. 729). Allowance, however, is made by the writer for different diameters on account of the low velocities as per Table A. Thus each elbow is equal in equivalent length of pipe in feet to twice the diameter in inches. For friction loss at exit of feed water from boiler as also return water out of radiator a length equivalent to that of 1½ elbows should be used. For connections off of mains when the main doe

not reduce at the connection, a length equivalent to three elbows is assumed by the writer as friction of entrance into feed connections and resistance in return connection. When a reduction is made two elbows are allowed instead of three. In the case of risers, on account of the small size pipe used, an equivalent of four elbows where there is no reduction and three elbows where is a reduction should be allowed. When deflecting fittings are used in the risers 1½ elbows should be allowed and ½ elbow in the riser above deflecting fitting. For radiator valves an equivalent of 1½ elbows should be allowed. There is no information available as to the above frictional resistances of connections and until such can be obtained the above values can be safely used. It is found, however, that in ½-inch connections it is better to use a ¾-inch connection and then reduce to ½ inch.

TABLE A.

Dia.	Add.
½	1 l
¾	3/4 "
1	2/3 "
1¼	1/2 "
1½	1/3 "
2	1/5 "
2½	1/6 "
3	1/8 "
3½	1/10 "
4	1/14 "
4½	1/16 "
5	1/25 "
6	1/33 "
7	1/50 "
8	0 "
9	−1/50 "
10	−1/25 "

SOLUTION FOR TWO-PIPE SYSTEM

The solution of the two-pipe system, Plan II, is shown as follows. It is necessary to assume the sizes throughout. This can very easily be done approximately after working out a number of plans. An assumption of one size larger or smaller, or even two sizes, than the true value does not appreciably affect the results, provided, of course, there are not too many discrepancies. If there are any large discrepancies corrections must be made.

The assumption of the diameter is merely made to obtain a value for l, the length, and has nothing to do with the diameter resulting from the formula. It will be found that the variation in l due to an error in assumption of the diameters will be very small, less than 10 per cent. and has no appreciable effect on the results.

The practical problem worked out in this paper has been worked out assuming almost all the diameters exact, so as to allow of inspection of the very small difference which would result had the diameter been assumed too large or too small. Plan I shows the radiation and heights from center of boiler proper to the different radiators.

Sheets I and II show how the values for $l \div C$ for the various parts of mains and risers are determined. Following a line across the sheet, it will be seen that first comes radiation on part under consideration, then assumed size, then l (including elbow equivalent), then $l \div C$, then $12C'_4\sqrt{H} \div v^{\frac{1}{2}}$ as determined by the equations, then the value of $12C'_4C\sqrt{H} \div v^{\frac{1}{2}}$ (the diameter), then the "made" diameter.

TABLE B.

Difference in Temp. T	$\sqrt{\frac{4}{\pi C_1 T 3600 C'_4}}$	$\frac{\gamma_2 - \gamma_1}{C_3}$	$\frac{C'_4 C_3}{C_2}$
5	.0011	.11	.0045
10	.00076	.21	.0060
15	.00062	.32	.0075
20	.00054	.42	.0085
25	.00048	.52	.0094
30	.00044	.62	.0103
35	.00041	.71	.0110
40	.00038	.81	.0120
$C_1 = 61.00$ $\gamma_1 = 60.66$ (at 175°) γ_2 varies from this down. $f = .007$			

It is impossible to obtain pipe in the market which will give exact diameters, as figured above. Consequently good judgment must determine whether the next size shall be

used or whether a part shall be made one size smaller and a part one size larger. This proportion could be exactly determined, but the result is not worth the trouble. Sheet 3 shows the equations worked out similar to general equation 14. It is seen that the 36 square foot radiator determines the size of the main. From this equation find $v_r^{\frac{5}{2}}$, then multiply this into the $\Sigma \frac{l_M}{C_M}$ on the right side of the equations, place result immediately under the first member of the right side of the equations, subtract and place above the member of left side of equation. Divide this and we have $v_r^{\frac{5}{2}}$ from which we obtain $v_r^{\frac{1}{2}}$ and then the corresponding d_r.

All systems can be worked out in this manner. The length of this paper, however, will not permit of working out these systems or going into discussion of the drop in temperature in mains, due to radiation as affecting the radiation and circulation, the assumption of γ_1 and γ_2 at their corresponding temperatures as affecting the various coefficients and the many other conditions which arise in a system of hot-water heating. Suffice it to say, however, that this method of figuring pipe sizes has been used by the writer in all of his installations. Many new problems are repeatedly coming up and from the experience of their installations new information is to be gained which may add in time to the improvement of this formula.

MAIN EQUATION 3.

		V_2^5	V_2^1
I. 72	$\frac{0.737}{6.47} = 0.905 - \frac{3.50}{0.168\ \ 1.34}$	0.114	0.65
100	$\frac{0.674}{5.2} = 0.905 - \frac{4.84}{0.231\ \ 1.29}$	0.130	0.665
II. 18	$\frac{2.16}{17.20} = 2.45 - \frac{6.13}{0.29\ \ 1.33}$	0.125	0.66
36	$\frac{0.279}{5.84} = 0.635 - \frac{7.46^*}{0.356\ \ 0.71}$	0.048	0.545
III. 85	$\frac{0.515}{7.58} = 0.905 - \frac{8.17}{0.390}$	0.068	0.585
80	$\frac{0.515}{8.50} = 0.905 - \frac{8.17}{0.390}$	0.061	0.57
	$\frac{0.635}{13.30} = 0.048$	0.048	0.545
I. 64	$\frac{1.751}{6.71} = 1.322 + 3.78 \times 0.114$	0.261	0.765
I. 60	$\frac{2.325}{9.08} = 1.215 + 4.25 \times 0.261$	0.256	0.76
I. 56	$\frac{2.635}{12.30} = 1.215 + 5.55 \times 0.256$	0.214	0.735
II. 18	$\frac{2.015}{17.00} = 1.215 + 6.37 \times 0.125$	0.118	0.65
III. 75	$\frac{0.332}{4.97} = 4.88 \times 0.068$	0.067	0.58
III. 65	$\frac{1.654}{6.11} = 1.322 + 4.88 \times 0.068$	0.271	0.77
III. 60	$\frac{1.175}{4.52} = 4.34 \times 0.271$	0.260	0.765
III. 75	$\frac{2.390}{6.89} = 1.215 + 4.34 \times 0.271$	0.347	0.81
III. 70	$\frac{1.44}{4.18} = 4.75 \times 0.347$	0.344	0.81

EQUATIONS.

Average Temp. in Rad. = 180°

$T = 20°$ $\qquad \frac{C'_4 C_2}{C_2} = 0.0085$ $\qquad C'_4 = 0.00054$ $\qquad H = 165,\ \sqrt{H} = 12.8$

$0.0085 \times 12.8 \times 5.83 = 0.635$ $\qquad C'_4 \sqrt{H} \times 12 = 0.083$
$0.0085 \times 12.8 \times 8.33 = 0.905$
$0.0085 \times 12.8 \times 11.16 = 1.215$
$0.0085 \times 12.8 \times 12.16 = 1.322$
$0.0085 \times 12.8 \times 22.50 = 2.045$

SHEET 1.
Two Pipe System—Plan II.

MAINS.

RADIATION.	SIZE ASSUMED.	l	$\frac{l}{C}$	$\frac{12\,C'_4\sqrt{H}}{v^{\frac{1}{4}}}$	d	MADE.
Sq. Ft.	*Inches.*					*Inches.*
934	4½	$6\frac{1}{2} - e = \frac{l = 42}{59}$ / $101 + \frac{1}{16} = 107$	$\frac{107}{\sqrt{934}} = \frac{107}{30.54} = 3.50$	0.152	4.65	4½
682	4	$0 - e = \frac{l = 32}{0}$ / $32 + \frac{1}{14} = 35$	$\frac{35}{\sqrt{682}} = \frac{35}{26.14} = 1.34$	0.152	3.98	4
582	4	$0 - e = \frac{l = 29}{0}$ / $29 + \frac{1}{14} = 31$	$\frac{31}{\sqrt{582}} = \frac{31}{24.12} = 1.29$	0.152	3.67	3½
546	3½	$0 - e = \frac{l = 28}{0}$ / $28 + \frac{1}{16} = 31$	$\frac{31}{\sqrt{546}} = \frac{31}{23.33} = 1.33$	0.152	3 55	3½
510	3½	$0 - e = \frac{l = 14}{0}$ / $14 + \frac{1}{16} = 16$	$\frac{16}{\sqrt{510}} = \frac{16}{22.59} = 0.71$	0.152	3.44	3½

RISER I—VERTICAL PARTS.

252	2	$6 - e = \frac{l = 12}{24}$ / $36 + \frac{1}{8} = 43$	$\frac{43}{\sqrt{252}} = \frac{43}{15.85} = \begin{array}{r}2.71\\3.78\\\hline 6.49\end{array}$	0.128	2.02	2
180	1½	$\frac{1}{2} - e = \frac{l = 22}{1\frac{1}{2}}$ / $23\frac{1}{2} + \frac{1}{3} = 33$	$\frac{33}{\sqrt{180}} = \frac{33}{13.40} = \begin{array}{r}2.46\\4.25\\\hline 6.71\end{array}$	0.110	1.46	Feed = 1½ Ret. = 1¼
116	1¼	$\frac{1}{2} - e = \frac{l = 24}{1\frac{1}{2}}$ / $25\frac{1}{2} + \frac{1}{2} = 38$	$\frac{38}{\sqrt{116}} = \frac{38}{10.78} = \begin{array}{r}3.53\\5.55\\\hline 9.08\end{array}$	0.109	1. 18	Feed = 1¼ Ret. = 1

RISER I—CONNECTIONS.

72	1	$7\frac{1}{2} - e = \frac{l = 4}{15}$ / $19 + \frac{2}{3} = 32$	$\frac{32}{\sqrt{72}} = \frac{32}{8.48} = 3.78$	0.128	1.08	1
64	¾	$9\frac{1}{2} - e = \frac{l = 3\frac{1}{2}}{15\frac{1}{2}}$ / $19 + \frac{3}{4} = 34$	$\frac{34}{\sqrt{64}} = \frac{34}{8\ 00} = 4.25$	0.109	0.87	¾
60	¾	$7\frac{1}{2} - e = \frac{l = 14}{11}$ / $25 + \frac{3}{4} = 43$	$\frac{43}{\sqrt{60}} = \frac{43}{7.75} = 5.55$	0.109	0.846	¾
56	¾	$10\frac{1}{2} - e = \frac{l = 37}{16}$ / $53 + \frac{3}{4} = 92$	$\frac{92}{\sqrt{56}} = \frac{92}{7.48} = 12.30$	0.113	0.844	¾

RISER II—VERTICAL PARTS.

36	¾	$7 - e = \frac{l = 34}{10}$ / $44 + \frac{3}{4} = 77$	$\frac{77}{\sqrt{36}} = \frac{77}{6} = \begin{array}{r}12.83\\6.37\\\hline 17.20\end{array}$	0.126	0.755	¾

RISER II—CONNECTIONS.

18	½	$9\frac{1}{2} - e = \frac{l = 4}{9\frac{1}{2}}$ / $13\frac{1}{2} + 1 = 27$	$\frac{27}{\sqrt{18}} = \frac{27}{4.24} = 6.37$	0.127	0.542	½
18	½	$8\frac{1}{2} - e = \frac{l = 28}{8\frac{1}{2}}$ / $36\frac{1}{2} + 1 = 72$	$\frac{72}{\sqrt{18}} = \frac{72}{4.24} = 17.00$	0.126	0.534	½

SHEET II.

Two Pipe System—Plan II (Continued.)

Riser III—Vertical Parts.

Radiation.	Size Assumed.	l	$\frac{l}{C}$	$\frac{12\,C'_4\sqrt{H}}{v^{\frac{1}{4}}}$	d	Made.
Sq. Ft.	*Inches.*					*Inches.*
430	3	$l = 14$ $6 - e = 36$ $\overline{50} + \frac{1}{3} = 56$	$\frac{56}{\sqrt{430}} = \frac{56}{20.71} = 2.70$ 4.88 $\overline{7.58}$	0.142	2.94	3
270	2	$l = 24$ $0 - e = 0$ $\overline{24} + \frac{1}{3} = 29$	$\frac{29}{\sqrt{270}} = \frac{29}{16.41} = 1.77$ 4.34 $\overline{6.11}$	0.110	1.81	Feed = 2 Ret. = 1½
145	1½	$l = 22$ $0 - e = 0$ $\overline{22} + \frac{1}{2} = 33$	$\frac{33}{\sqrt{145}} = \frac{33}{12.04} = 2.74$ 4.15 $\overline{6.89}$	0.103	1.235	Feed = 1¼ Ret. = 1

Riser III—Connections.

75	1¼	$l = 6$ $9 - e = 23$ $\overline{29} + \frac{1}{2} = 43$	$\frac{43}{\sqrt{75}} = \frac{43}{8.66} = 4.97$	0.143	1.24	Out. = 1¼ Conn. = 1
85	1¼	$l = 7$ $9 - e = 23$ $\overline{30} + \frac{1}{2} = 45$	$\frac{45}{\sqrt{85}} = \frac{45}{9.22} = 4.88$	0.142	1.31	1¼
60	¾	$l = 6$ $9 - e = 14$ $\overline{20} + \frac{1}{4} = 35$	$\frac{35}{\sqrt{60}} = \frac{35}{7.75} = 4.52$	0.109	0.84	¾
65	¾	$l = 6$ $9 - e = 14$ $\overline{20} + \frac{1}{4} = 35$	$\frac{35}{\sqrt{65}} = \frac{35}{8.06} = 4.34$	0.108	0.87	¾
70	¾	$l = 8$ $8 - e = 12$ $\overline{20} + \frac{3}{4} = 35$	$\frac{35}{\sqrt{70}} = \frac{35}{8.36} = 4.18$	0.103	0.86	¾
75		$l = 9$ $8 - e = 12$ $\overline{21} + \frac{3}{4} = 36$	$\frac{36}{\sqrt{75}} = \frac{36}{8.66} = 4.15$	0.103	0.887	¾

First Floor and Basement Connections.

100	1¼	$l = 10$ $10 - e = 25$ $\overline{35} + \frac{1}{2} = 52$	$\frac{52}{\sqrt{100}} = \frac{52}{10} = 5.2$	0.125	1.25	Over = 1¼ Up = 1
36	¾	$l = 6$ $9 - e = 14$ $\overline{20} + \frac{3}{4} = 35$	$\frac{35}{\sqrt{36}} = \frac{35}{6} = 5.84$	0.152	0.913	Over = 1 Conn. = ¾
80	1¼	$l = 26$ $10 - e = 25$ $\overline{51} + \frac{1}{2} = 76$	$\frac{76}{\sqrt{80}} = \frac{76}{8.95} = 8.50$	0.146	1.30	1¼

DISCUSSION

MR. SCHLEMMER—The theory of this formula as worked out on the accompanying sketch is based on the difference in weight in the return pipe and the feed pipe and is the same as the action of a pump. That is the entire theory.

I have found in my experience in the last eight years that we have been involved a good deal on short circuits. It has been a big expense to the company and I know every heating contractor has been through the same thing. So I decided to work out something. This is complicated, yet it is clear if you get down to it.

ROBERT A. WIDDICOMBE—Will it be possible to give less drop in the risers and more drop in the main and change the form of the equation?

MR. SCHLEMMER—Yes.

MR. WIDDICOMBE—Would not that break the practice you speak of and bring the risers up?

MR. SCHLEMMER—No. You will find, if you assume a higher velocity, that that will become negative, and that means that there is not enough head to circulate the water at that velocity through the basement ceiling radiator.

PROFESSOR KINEALY—Mr. Schlemmer puts his velocity in feet per second, and yet you hear us speak of velocity in feet per minute. D is the diameter of the pipe in feet and nobody ever uses such a unit. It would be a great help if these formulæ could be given in the units we ordinarily use.

MR. SCHLEMMER—I have taken these units from hydraulic engineering. They always figure out length, feet and diameter. In jobs I have installed according to this formula I have found a difference of temperature in the main and return to be as low as 20°.

PROFESSOR ALLEN—How did you determine your coefficient of friction? I have worked on it for about three years and I am still up in the air.

MR. SCHLEMMER—When I first used this formula I used .007 and that was a coefficient everybody used for water work. I found on the small pipes, ¾ inch and ½ inch, there was a difference which I could not notice on the 1½ and 2 inch. That made me believe that the diameter had something important to do with the coefficient of friction. That is why I took D'Arcy's formula.

TOPICS 1, 2 AND 3

"The Relative Efficiency and Velocity in Two Air Pipes, One Having a Vertical Rise of 18 *Inches to a Round Elbow Supplying a Pipe Running Horizontal for* 10 *Feet, the Other Having a Uniform Upward Inclination of* 18 *Inches in* 10 *Feet.*

"The Difference in Capacity to Be Provided in Warm Air Pipes Where Air Travels at Different Velocities.

"The Relative Size of Hot Air Pipes Carrying the Same Volume of Air at Velocities of 100, 150, 200 *and* 300 *Feet Per Minute."*

DISCUSSION

MR. GEO. D. HOFFMAN.—I should say that the velocity would be very much greater in the inclined pipe than in the vertical pipe with the horizontal run. The cause of the velocity in a hot air pipe is simply the difference in specific gravity of a cold column of air and a hot column of air, the difference being so slight that the least obstruction tends to retard the velocity. It has been my experience, not so much in measuring the velocity of air currents through pipes similarly planned, but in determining the freedom of air coming into the cold air duct, that in a cold air duct which is carried along the ceiling to a point adjacent to the furnace, wherever there was a square turn in the direction of the air current at the point of drop, there would be a loss both in velocity and volume, but the job would work perfectly if the air was on a gradual decline towards the base of the furnace.

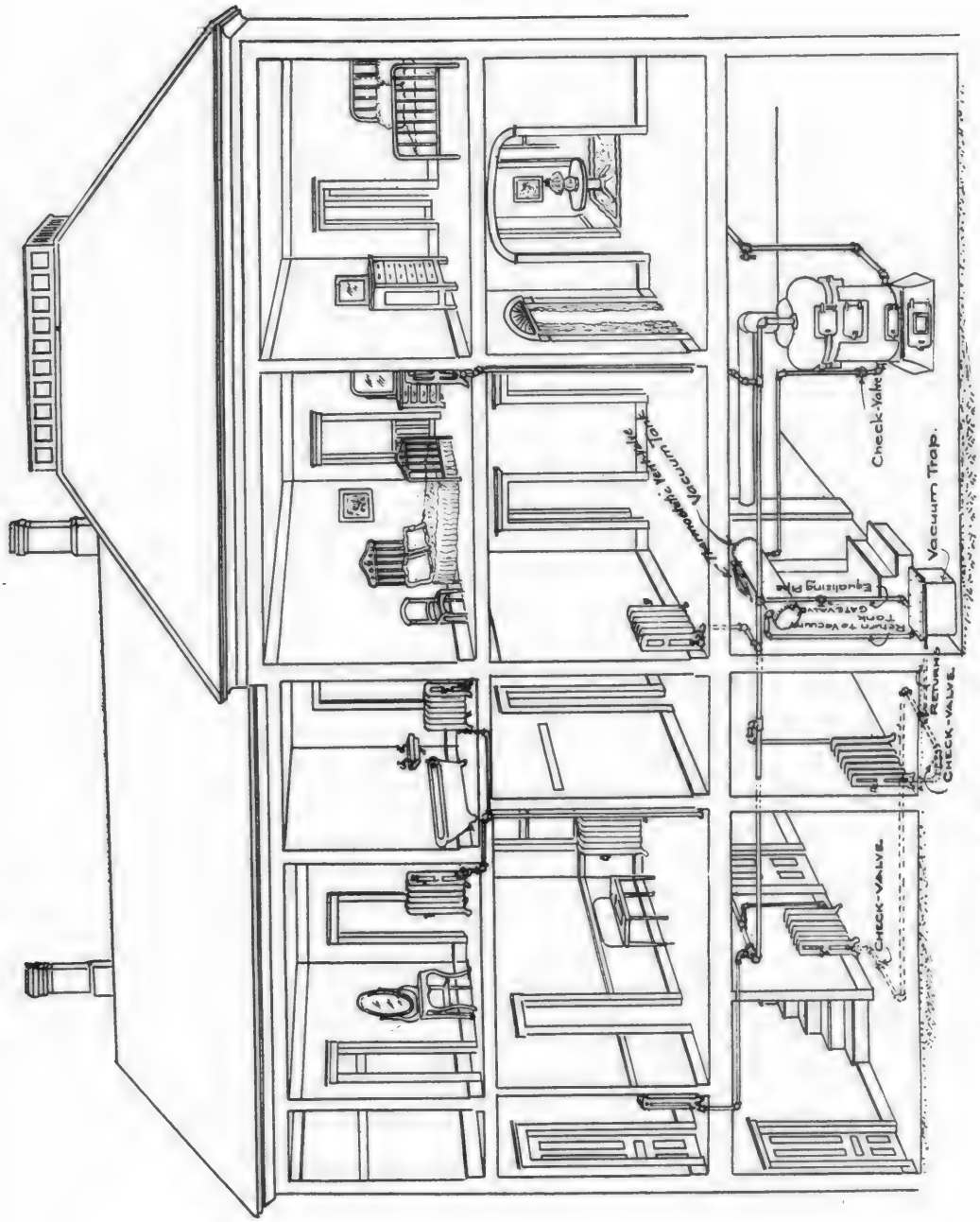
MR. SAMUEL R. LEWIS.—Mr. Thompson, who started this argument at a former meeting, illustrated a job in which, I think, the rise was something like 5 feet and the horizontal run something like 25 feet. This operated perfectly. The theory was that the column of warm air coming up out of the bonnet of the furnace in this vertical duct gave an impetus that forced the cool air through the pipe. I believe there is something in that, in some instances.

VICE-PRESIDENT MACKAY.—It is simply the momentum created, but I think the same pipe would do better than if you went up 18 inches on an incline and then crossed.

MR. G. D. HOFFMAN.—I am somewhat of a vacuum crank, on steam heating propositions at the present time, but I want to say positively that as regards the question of air moving, there is no such thing as a vacuum in an air chamber. It is always the lifting power of the cold air that causes the warm air to move out of the furnace chamber, and it is always considered good practice in furnace heating to put on what we call a side-collar connection in preference to a top connection, where the pipes have to run horizontally after leaving the top of the furnace, and the only reason, in low basements, for the top collar connection is simply on account of the head room. If there is room enough to get around the furnace, a side collar connection is almost always used.

MR. F. K. CHEW.—I want to support what Mr. Hoffman has said. I favor the use of a pipe having an incline as compared with one having a vertical rise.

MR. G. D. HOFFMAN.—I really believe, with low velocities of air, the two sys-



VACUUM SYSTEM IN DWELLING FOR HEATING RADIATORS ON BOILER LEVEL.

tems will be pretty nearly the same, but where the velocity is fairly large, while the friction in the horizontal runs would be practically the same in each pipe, the high velocity of the air would cause the particles of air to strike the square elbow, which would practically stop them, and the air would have to receive the renewed velocity.

MR. JAMES A. DONNELLY.—When this topic was discussed in Chicago, Mr. Thompson said the benefit, if any, came from using 45 degree elbows, rather than square elbows, and he said that the longer the radius of the elbow, other things being equal, the better, but that when he used right angle elbows they were with as long reaches as possible. It is not good practice to run hot water mains at an angle of 45 degrees. If a vertical rise of 18 inches in a circuit is made, I think the circulation is as good as if the pipes were run on an incline. I think the same laws of velocity and friction apply to the flow of air. If you get an impact against a square elbow, you have to put a few more joints in the elbow. Why is it necessary to have more pitch for hot water pipes than with hot air pipes? I do not think it is necessary myself.

MR. S. R. LEWIS.—I agree with Mr. Donnelly that the two are very similar, water and air. It is the head that does the business.

MR. C. E. OLDACRE.—The velocity of the water traveling through a pipe is usually a great deal less than the velocity of air. The different effect could be illustrated by a person walking and making a turn very rapidly and making the same turn very slowly. He meets with no resistance turning slowly, whereas if he is going at a rapid rate he meets with an obstruction.

MR. L. A. LARSEN.—If you get a rise of four feet you are all right, but a rise of 18 inches will not help you much in the way of giving you sufficient head.

MR. CHARLES G. FOLSOM.—Pipe taken off from the top of the furnace never works as well as those taken off the side of the hood.

MR. LARSEN.—Suppose we want to use an indirect radiator in place of a furnace, and are carrying the air from an outside window, say, 35 feet into the basement, would it be better to place an indirect radiator near the window, close to the intake, or near the base of the flue? Where would be the best place for the indirect radiator?

VICE-PRESIDENT MACKAY.—I should say near the base of the flue, because there would be no loss of heat in transmission of the air from the intake to the base of the flue, while the air would be, to a certain extent, heated by the air of the cellar on its way to the indirect radiator. Otherwise, the reverse takes place because the temperature of the air after leaving the radiator would be higher than the air of the cellar.

MR. E. F. CAPRON.—My practice has been to put the indirect radiator as near the base of the flue as possible.

MR. OLDACRE.—Referring to Topic 2, I have made a number of experiments with aerometers to determine the velocity of air coming through a register in hot air furnaces and blast plants and, as far as hot air furnaces are concerned, the velocity will vary greatly under different conditions, and no stated rules can be laid down as to the velocity of air coming from a hot air register. It depends not only on the difference in the outside and inside temperature of the air, but very largely on the direction of the wind or the velocity of the wind. If the air duct is proportioned to give two-thirds the area of the hot air pipe, as is sometimes done when the air is taken entirely from the outside, and if there is a good wind blowing, there is an excessive velocity and a reduced temperature. So that there is no theoretical consideration by means of which it can be figured out. As near as I could find, after about 200 tests, they varied so greatly with the same sizes, under practically the same conditions, same heights and same elevations, that there seemed to be no method of arriving at any exact data.

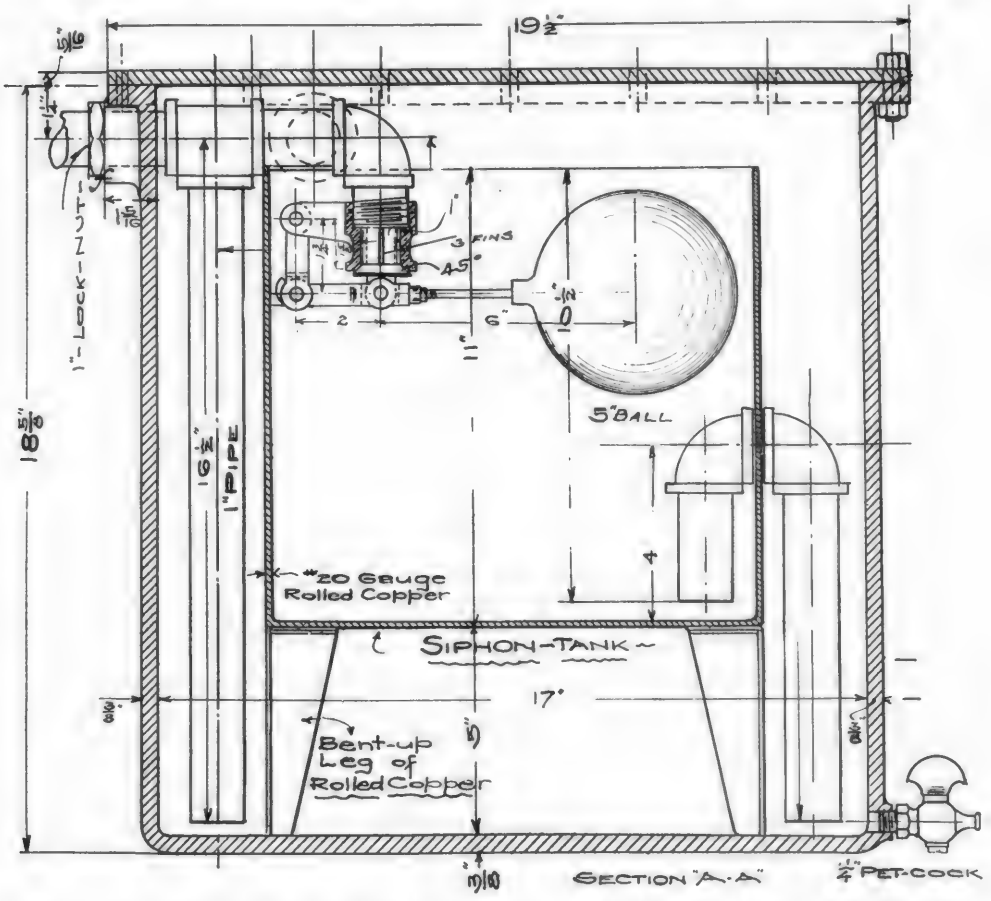
MR. WM. G. SNOW.—When I was engaged in the furnace business, some years ago, we used to allow roughly a velocity of, say, 250 or 275 feet per minute, possibly more, to rooms on the first floor and, roughly, a velocity of 400 feet in pipes leading to the second floor. As a rule, we did not allow a much higher velocity to rooms on the third floor, perhaps 500 feet. These, of course, are very rough figures, but I really think the figures of 275 feet velocity through the furnace pipes leading to the first floor and 400 feet to those leading to the second floor, in severe winter weather, represents, perhaps, as nearly as may be, the velocities that you would expect to find with an aerometer, averaging all the velocities of all the registers on the first floor and all of those on the second floor.

In the finest residence work I ever laid out, indirect hot water, which worked very satisfactorily, the flues were proportioned on a basis of 275 feet velocity for the first floor, 375 feet for the second floor and 475 feet for the third. In that job the temperature of the radiators was higher than usual.

VICE-PRESIDENT MACKAY.—Would you say that the higher velocity was owing to the higher temperatures?

MR. SNOW.—Yes, but the tendency nowadays is toward lower temperatures in heating work of every kind.

MR. G. D. HOFFMAN—About a year ago a gentleman from New Orleans came into our office and said he was very anxious to heat his house with steam, but owing to the fact that there were no cellars in that locality, he would be compelled to set the boiler on the same level with the radiators if he placed the radiators on the floor, and the question was asked me, if steam could be circulated through radiators on the same level with the boiler. The accompanying sketch (page 20) is my reply to the query.

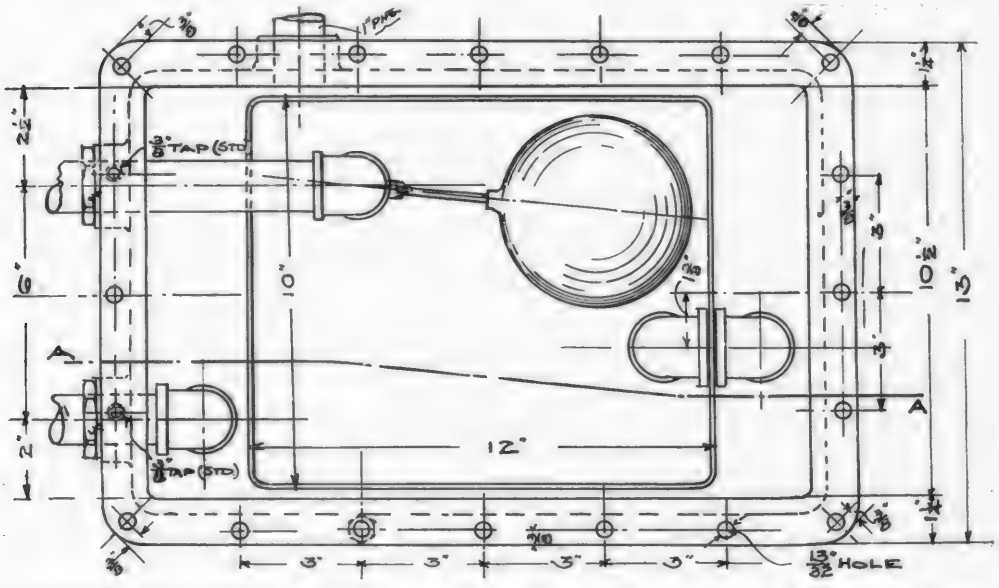


SECTIONAL VIEW OF VACUUM TRAP USED IN SYSTEM FOR HEATING RADIATORS ON BOILER LEVEL

When steam reaches the connections to the radiators located on the basement floor, it flows into them the same as if the radiators were connected on the floor above. The only trouble with a connection of this kind, originally speaking, would be that the radiators would soon fill with water from the condensation. In the accompanying sketch it will be noted that the radiators are connected to a vacuum trap, and the connecting pipe is so inclined that the water of condensation flows by gravity into the vacuum trap. This vacuum trap has two other pipes leading into it, one of which is called the equalizing pipe, which is connected to the steam main. The other pipe is called the return pipe to vacuum tank and leads from the vacuum trap to the top of a tank designated "vacuum tank" in the drawing, which is located at a point considerably above the water line in the boiler. Inside of this vacuum trap, as shown by the detailed drawing, is placed an open pan in which is located a float valve which controls the return to the vacuum tank. It will be noted that the equalizing pipe from the live steam main opens directly into the top of the vacuum trap and the steam from this pipe, when the open pan in the vacuum trap is emptied and the float valve open, passes directly from the equalizing pipe through this float valve into a vacuum tank, expelling all of the air in this vacuum tank through the thermostatic vent valve which is located on the top of the vacuum tank. As the water of condensation flows through the connecting pipe into the vacuum trap it in time overflows into this open pan until it is of sufficient height in the pan to close the float valve. It will also be

noted that a connection is made to the bottom of the vacuum trap from the return pipe to the vacuum tank outside of the open pan. This pipe is open at its lower end, but when the trap is full of water this pipe is submerged. When, as above noted, the water in the open pan closes the float valve the steam in the vacuum tank begins to condense with a consequent reduction of pressure in this tank. The thermostatic vent valve on the top of the vacuum tank is also a vacuum valve, that is, a valve which automatically closes against the ingress of air into this tank as pressure goes off.

The result of this reduced pressure in the vacuum tank is an unbalancing of the pressures in the vacuum tank and



PLAN OF VACUUM TRAP USED IN SYSTEM FOR HEATING RADIATORS ON BOILER LEVEL

in the vacuum trap with a result that as soon as the difference in pressure between the vacuum tank and the vacuum trap equalizes the weight of the column of water in the return pipe from the vacuum trap, the water will begin to flow from the vacuum trap into the vacuum tank.

As soon as all of the water is displaced in the main part of the vacuum trap, the syphon shown in connection with open pan in the vacuum trap dumps the water out of this pan into the main part of the trap. The float valve, having nothing to support it, opens, which immediately permits an equalization of pressure between the vacuum trap and the vacuum tank and, as the pressure on the vacuum trap is equal to that of the boiler, the water in the vacuum tank will then flow back by gravity through the connecting pipe to the boiler. Of course, it is possible to do this same thing with several kinds of traps, but among all of the traps I know of you have to have a certain amount of pressure in order to operate them. With this device you do not have to have any pressure at all, practically speaking. Anything above a half pound will operate it perfectly.

VICE-PRESIDENT MACKAY.—Is not that a sort of application of the steam loop?

MR. HOFFMAN.—In one way, yes; only I use vacuum in that upper tank to draw out the water.

VICE-PRESIDENT MACKAY.—A vacuum is created drawing condensation up from the radiators and discharging it into the boiler.

PROF. J. D. HOFFMAN.—It looks to me as though Mr. Hoffman has the steam loop, as you suggest. We know the steam loop, under certain conditions, will work in about the place he has shown. We know also there must be a certain relation between the areas and the two pipes leading to the tank; the one to the left and the one to the right.

MR. DONNELLY.—Mr. Blessing of Albany, who invented the return trap, has recently published a booklet giving the history of the steam loop* and a history of the return trap, and I think Mr. Hoffman has given that with little variations.

MR. SNOW.—If anyone wishes to look into the steam loop, he will find an interesting paper written by Mr. Wallace Kerr, published some years ago in the transactions of the American Society of Mechanical Engineeers. Mr. Kerr is president of

*Published in THE HEATING AND VENTILATING MAGAZINE for June, 1906.

Westinghouse, Church, Kerr & Co., in New York. When I was in Philadelphia we put the steam loop in the Bellevue-Stratford Hotel, which is to-day a representative piece of work, eliminating all traps. Another point that may be of some interest is that we used no separators whatever, except the blanket tank combined separator on the exhaust system before it went to the heating pipe. The piping is laid out with a complete ring or loop and cut-out valve between every two pieces of apparatus, whether boilers or engines, and when we rise to come over to an engine a cross is used, and in every one of those is a drip pipe connecting with the steam loop.

VICE-PRESIDENT MACKAY.—Are those mufflers also drained?

MR. SNOW.—That is merely a big acquirer at the base of an 18-inch exhaust system, and over that a feed system is provided with a main off into the attic, distributing through the different wings of the building.

TOPIC NO. 4.

The Amount of Radiation Necessary to Maintain 70° in a Building Having Movable Glass and an Excessive Air Leakage and in One Having Weather Strips, Practically Avoiding Air Leakage.

(No discussion.)

TOPIC NO. 5.

The Chemical and Physical Properties of Cast Iron Used in Boilers and Radiators.

VICE-PRESIDENT MACKAY.—There can be no question that there is a great deal of difference in cast iron. Different manufacturers use different mixtures. I do not know that there can be anything said as to cast iron not being as efficient as an emitting agent as it is a heat-absorbing agent.

PROF. ALLEN.—I think the form of the surface has far more to do with the amount of heat loss per square foot than the material from which the surface is made. The amount of heat transmitted through wrought iron pipe and through cast iron pipe is practically the same.

VICE-PRESIDENT MACKAY.—I have found you must use good, clean No. 2 Foundry cast iron. Some people use some solvent. Poor iron, with high temperatures, crystallizes, especially when there are right angle turns, and it is liable to fracture under those conditions. But as boilers are made to-day, with the material used in them, the iron eliminates that condition.

SECRETARY MACKAY.—My opinion is in making cast iron radiators and boilers, that the iron that will run profitably is satisfactory for the uses to which it is put, iron that you cannot injure with the fire while water is back of it, and the radiator that is made from iron which will run commercially into a radiator is satisfactory for heating purposes. It is a mistake to assume that there is anything in a chemical analysis of that iron that would injure its properties as a heating medium.

MR. WEINSHANK.—Is it the opinion of the society that the best cast iron makes the best radiator? If so, how is it practicable from a commercial standpoint? We usually estimate the cost of an engine by its weight. We say the cost of an engine will run 15 cents a pound. Another casting will cost 7 or 8 or 9 cents a pound. We roughly come down to a thumb rule where we estimate the cost of certain apparatus or machines made of cast iron at so much per pound. If we come down to the same basis of estimating on radiators, we will have the commercial iron at about 7 cents, instead of 3 cents a pound on cast iron. If they use good ore, where will the manufacturers come out at the end of the year? Therefore, we must assume that they use scrap iron.

MR. S. KAUFMAN.—I do not believe a radiator or boiler manufacturer can afford to use much scrap iron in the manufacture of a radiator, because it will be too hard, and if you get a hard casting you will have very easy cracking in the milling of the radiator.

SECRETARY MACKAY.—Any manufacturer of radiators knows that he must use a certain amount of scrap iron to make the mixture, but he cannot use as much scrap as Mr. Weinshank intimates, because of difficulties in castings when making the radiator. It must be soft enough to run without hard spots in it, and it must be soft enough to be milled and fitted at the joints.

TOPIC NO. 6.

The Relative Advantage of a Wet or Dry Return to a Boiler Set at the End of a Long, Narrow Building in a Gravity System, and the Advantages of Extending the Main a Long or Short Distance Beyond the Last Radiator Connection.

DISCUSSION.

SECRETARY MACKAY.—I think the author of this question had trouble with a steam heating apparatus where the boiler was located at one end of the building, and he had a long steam main coupled with a long return back to the boiler and dropping down, and that he had trouble lifting water to his last radiator. My opinion is that it is often a case of having too little water in the boiler for the amount of radiation that is on the boiler, and that part of the trouble is experienced by improperly venting that main. People claim to have overcome the trouble by taking that dry return and making it a wet return. To my mind, all that they are doing is increasing the volume of water in the system, or supplying the volume of water that was necessary and should have been in the boiler originally. Where they have used a bullhead tee, on the end of the steam main going up to the last radiator and down to the dry return, they have lifted water to that radiator, and putting

what they call a pass by, a tee, a nipple and an elbow, there was less possibility of lifting the water when placed in that manner. I think the author of the question also wanted to know whether it was an advantage to go beyond the radiator any distance.

MR. P. J. DOUGHERTY.—What velocity would it be advisable to maintain going up to the last radiator?

MR. DONNELLY.—In a paper last January a statement was made that a velocity exceeding 40 feet a second in vertical pipe would carry up drops of water not in contact with the pipe. That is based upon laws of gravity and friction, and was checked at the meeting by Professor Baldwin, who said he had not found any case where a velocity of 40 feet a second was exceeded with good results. I think that velocity is dependent to some extent on the size of the pipe.

I can give the members a rule or formula for return pipe sizes. I think either a wet or a dry return will circulate properly if the piping is of the proper size.

We will assume that the steam main is designed for a certain drop in pressure per 100 foot run and that it is desirable that the return shall be designed for the same drop. If it is to be a wet return the corresponding rating will be proportional to the square root of the comparative density between steam and water. As water at 212° is about 1,600 times as heavy as steam at atmospheric pressure, a wet return pipe will carry 40 times as much radiation as the steam rating with the same pressure loss from friction.

In figuring the proper rating for pipes as dry return it is necessary to assume how much surface they will have in order to know how much steam they will be required to carry in order to supply the heat radiated by them.

If 1,640 cubic feet of steam are fed into a radiator and 1,600 cubic feet are condensed and passed into the return as well as 40 cubic feet of uncondensed steam, the size of pipe required to carry either the water or the steam will be the same; since the steam is 40 time the volume of the water and flows at 40 times the velocity with the same loss from friction.

From this we see that the size pipe required to pass 2½ per cent. of the amount of steam condensed by the radiator is equal to that required by the water of condensation from the radiator (neglecting the gain due to differences in elevation as regards the condensation) and the following formula is very readily deduced:

$r = R\frac{40}{1+.4N}$. In which r=the rating of a pipe as a wet or dry return, R=steam rating of the same size pipe and N=percentage of surface of radiator in exposed return surface.

Now, if we set down the steam ratings as below and a few columns of return capacities as figured from the formula we will have something which may be very readily applied to laying out return pipe sizes.

If it is assumed that the returns when laid out properly will have about 10 per cent. of surface, then the return ra-

MAXIMUM CAPACITY OF RETURN MAINS.

Size inches "	Steam Rating	Wet Return X40	2½% Steam X20	5% Steam X13½	7½% Steam X10	10% Steam X8	15% Steam X5.7	20% Steam X4.4
½	5	200	100	66	50	40	29	22
¾	18	720	360	240	180	144	103	79
1	40	1,600	800	533	400	320	228	176
1¼	75	3,000	1,500	1,000	750	600	428	330
1½	126	5,040	2,520	1,680	1,260	1,008	718	554
2	286	11,440	5,760	3,813	2,860	2,228	1,631	1.258
2½	535	21,400	10,700	7,130	5,350	4,280	3,050	2,354
3	890	35,600	17,800	11,866	8,900	7,120	5,073	3,916
3½	1,360	54,400	27,200	18,133	13,600	10,880	7,752	5,984
4	1,950	78,000	39,000	26,000	19,500	15,600	11,135	8,580
4½	2.747	109,880	54,940	36,626	27,470	21,976	15,658	11,987
5	3,600	144,000	72,000	48,000	36,000	28,800	20,520	15,840
6	5,900		118,000	78,666	59,000	47,200	33,630	25,900
7	9,040			120,333	90,400	72,320	51,528	39,776
8	12.700				127,000	101,600	72,390	55,880
9	17,600						92,320	77,440
10	22,900						130,530	100,760
12	37,000							
14	55,300							
16	78,300							

diator connections and the return risers may be figured from the 10 per cent. column, the riser connections and the mains farthest from the source of supply may be figured from the 7½ per cent. or 5 per cent. column; this assumed percentage may be gradually reduced until finally when the return drops below the water line it may be sized from the wet return column.

To prove the correctness of the layout it will then be necessary to figure the actual return surface and perhaps re-figure accordingly.

If the returns are to be covered so that the radiation from them is to be but 50 per cent. that of bare pipe, the percentages of course may be likewise reduced.

The advantage gained by the pitch of the horizontal return pipes and the vertical drop of the water in the return risers will, of course, give quite a large factor of safety to this method of figuring and it is, therefore, believed to be quite conservative.

MR. WEINSHANK.—Under the same condition, under the same pressure, which would be more advantageous, to drop immediately or to drop after a certain length of space beyond the last connection?

MR. DONNELLY.—It is a question of velocity. If the system is properly laid out, I think such an expedient is not necessary. It is only in a case of poor practice of steam pipe sizes that we find the necessity of running past, and it is to cure that condition that ought not to exist that we do it.

TOPIC NO. 7.

The Benefits Derived from the Use of Fusible Plugs in Cast Iron Steam Boilers.

DISCUSSION.

SECRETARY MACKAY.—Some of the States compel the use of fusible plugs in steam boilers, whether they use cast iron or steel. From the way the member propounded this question, my opinion is that he has had some trouble with cast iron boilers; that, in spite of the fusible plugs, with low water, the boilers were cracked. I have had some experience due to what I felt was a wrong placing of the plug in the crown sheet of one of the sections. When the water got low, the plug melted out, but before the water could reach the opening it had to pass over red hot iron and cracked the section. I have done away with the practice of putting them there. My practice is to put the fusible plug in the back section of the boiler, facing forward, just below the crown sheet. When the water gets below that point in the crown sheet, or in any part of the boiler, it melts the plug and the water is driven out on the fire by the pressure of the boiler. I have not had a single case of breakage in boilers in the use of fusible plugs where they were located at that point, whereas I have known many cases of boilers fitted with fusible plugs where the plug was melted out and the sections were cracked by the admission of water after the melting out of the plug.

VICE-PRESIDENT MACKAY.—There are in different cities regulations regarding the location of the plug. The majority of them, I think, insist upon the plug being placed two inches below the water line. A great many people place the plug in the fire chamber, on what is called the crown sheet, a plug that will fuse only under fire when the water is low, or below the point at which the plug is connected. Some people use plugs in the water column with good results, placing them beneath the water column; the last mentioned plug being one that will fuse under a high temperature of steam. There has been a question whether a fusible plug is an advantage in a sectional boiler, run under 1, 2, 3 or 5 pounds of steam.

PROF. KINEALY.—I have always looked upon the fusible plug as a sort of detector. If a fusible plug is placed in a boiler so that it will fuse or open if the water is allowed to drop, say, two inches below where it ought to be, that means, when the plug is opened, the owner of the boiler knows that he has been derelict in his duty; he has to go to some one in authority and get the plug replaced.

TOPIC NO. 8.

The Advantages in Efficiency and Economy of One Large or Two Smaller Boilers for Carrying the Same Amount of Radiation, Assuming in Either Case Ample Capacity for the Work.

DISCUSSION.

SECRETARY MACKAY.—My experience is that you do not get the same economy in placing two boilers of small capacity on a given amount of radiation, unless one of the boilers is sufficient to carry the entire radiation without forcing in moderate weather. If you have 5,000 square feet of radiation on your building, and you have two 3,000 square foot boilers, there is never a time, even in moderate weather, when one of the boilers is sufficient to carry the entire load, whereas at any time the larger boiler is large enough for the work, and can be run under slower combustion during moderate weather and give all the results required, with greater economy than either one of the smaller boilers.

MR. J. A. DONNELLY.—It has been the practice of one boiler concern in the East to recommend, in as many cases as possible, the use of two boilers, for rather unusual reasons. They contend that it is good practice to get the air out of the radiators and keep it out by getting up the pressure, and they say the preferable way is to put in two boilers in a plant, each one ample to run it, and fire only one at a time, thus keeping up the steam by having a bright fire under one boiler while firing the other.

MR. W. G. SNOW.—I have in mind a case where a hot water system was put in with two boilers, and the complaint was made that they were burning an excessive amount of fuel. They were using both boilers in November. We shut down one boiler, and the result was, up to the middle of December, when the weather was not so severe as to require two boilers, the saving in fuel was considerable. So Mr. Mackay's remarks with regard to the single boiler being of sufficient capacity to carry all the radiation applies to steam heating, but would not apply, to my experience, in hot water heating, unless a decided gain was found in running two fires sluggishly in preference to having a bright, brisk fire under one boiler.

SECRETARY MACKAY.—The gentleman who propounded this question had in mind steam boilers. My way of overcoming the extreme size of one boiler has been to have two shaking bars on my grate, so that I could shake either the front or back bars, or both, as I wished.

TOPICS NOS. 9 AND 10.

The Comparative Fuel Consumption of Firebox Boilers in Brick Setting and Horizontal Tubular Boilers.

The Size of Standard Firebox Boilers Which Should Be Provided to Supply 1500 *Pounds of Steam Per Hour for Direct Radiation at Three Pounds Pressure, Burning Hard Coal, with a Sixty-Foot Chimney and Good Draft.*

DISCUSSION.

MR. L. A. LARSEN.—I am opposed to a fire-box boiler. I can get better results from a tubular boiler set in brick than I can from a fire-box boiler. The only reason for that is that I cannot get the gases to a proper degree of heat for combustion in a fire-box boiler on account of the close proximity of the water to the fire. While I was State Boiler Inspector for Minnesota, I ran across the case of a man who had a saw-mill, with a fire-box boiler. He would not have me inspect it because he said it was not large enough. I told him I would inspect the boiler and give him some advice, if he would take it. I said, "If you will turn the boiler around and put the grates in the other end and let the gases pass through the fire-box and use the box as a combustion chamber, you will have plenty of steam." Inside of two weeks, I went back that way and he had the boiler all fixed up as I had suggested and it was working very well.

MR. W. G. SNOW.—I would like to ask Mr. Larsen what kind of fuel he burns up there?

MR. LARSON.—We burn wood. As I stated, this was a saw-mill and we had nothing but slabs and saw-dust to burn.

MR. S. R. LEWIS.—When I was in general conversation with some fitters and engineers in the East, they seemed to imply that a fire-box boiler was not a good boiler. Out here we use a good many of them, particularly in Chicago. In heating department houses they are used very extensively.

MR. SNOW.—Mr. Lewis probably found, in talking with the people in the East who preferred to use the horizontal tubular boiler over the fire-box boiler, that they criticised the short fire-box or flue travel of the fire-box boiler, whereas with the horizontal tubular boiler the gases go under the boiler and then through the tubes, giving a longer time for contact of the gases with the water.

MR. J. A. DONNELLY.—Fire-box boilers in marine work, Cornish boilers and others, have extremely large combustion chambers for the fire, and the most successful ones are the flue boilers with large flues, so that the combustion is carried on in the flues, to some extent. There are two things which cause trouble with a fire-box boiler: the small combustion chamber and the close proximity of the small flues. A flue four inches or less in diameter certainly will act as a flame extinguisher. That criticism does not apply to a flue boiler where the flue is sufficiently large to allow combustion of the gases. That makes a great difference in many of that type of boilers. In regard to locomotive boilers, they are not used to any large extent in stationary work, because they are known to be too high fuel users.

SPECIAL TOPIC BY PROF. WILLIAM KENT.

It Is Said to Be a Fact that Many Houses Built to Sell Are Now Fitted with Hot Air Furnaces that Take All Their Air from the Hall and None from Out-of-Doors. If So, What Can Be Done by Our Society to Stop the Practice?

DISCUSSION.

MR. F. K. CHEW.—The feeling of the society on this point was very positively set forth at the meeting in Chicago two years ago when the society supported Professor Carpenter in his statement that the furnace system was abused on account of over-ventilation. There was no occasion to ventilate, he said, to the extent that the furnace system did ventilate and for that reason the rotation of the air was not a pernicious system by any means. The practice does not need to be stopped. It should be encouraged for the benefit of the public. However, I should strongly advocate the use of the cold air inlet for taking air from out-of-doors in the Spring and Fall.

VICE-PRESIDENT MACKAY.—Mr. Snow has written a book on furnace heating. He may be able to say something on the subject.

MR. W. G. SNOW.—Yes, and I mentioned that if we provided a return inlet, it was human nature for people to use the warm air all the time and get nothing from the outside. Therefore, I frowned it down: I said it would be better to pay for the heating of the cold air.

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FOUNDRYMEN, large and small have persisted of late in the policy of keeping out of the market, even the largest buying from week to week for prompt delivery. They were encouraged in their course by reports of lower prices of pig in some sections.

This condition of affairs, together with the gratifying volume of this season's business to date and the fairly certain indications of its continuation for the remainder of the season, finally compelled the manufacturers of boilers and radiators to make a penetrating inquiry as to the literal conditions prevailing and likely to prevail in the iron market.

As a result of this examination, it can be stated with fair certainty that there will be no lowering of prices of house-heating boilers or radiators during the balance of the season. In fact, there are many indications that a stiffening in the price of radiation is impending.

IN the discussion on another page of air washing and air washers, one of the most interesting facts brought out was the comparatively slow progress that has been made in the effort to mechanically cool buildings in a way that may be commercially possible. It was shown that the prosposition of mechanically cooling a building is not a difficult one at all, but the expense involved makes the cost of the most effective methods quite prohibitive, except as done occasionally. The use of ice, for instance, has been found to be too expensive for practical adoption, and, indeed, the only method seriously suggested was in connection with cold water.

A remarkable statement regarding the effect on water of passing warm air through it was that water so used will lose rather than add to its temperature.

OUR next issue will mark the date when a year ago we inaugurated the publication of monthly weather charts showing the fluctuation of the temperature, humidity and wind for each day of the month in a number of representative American cities—New York, Chicago, Boston, Pittsburg and St. Louis. We call attention to the matter at this time for the benefit of those who may be designing heating installations in those cities and who would find the information given in the charts of service to them. During the approaching heating season the weather records in the cities named will again form a regular feature of this magazine, their publication commencing with the November issue, which will contain the weather records for October.

Cooling an Auditorium by the Use of Ice

By John J. Harris

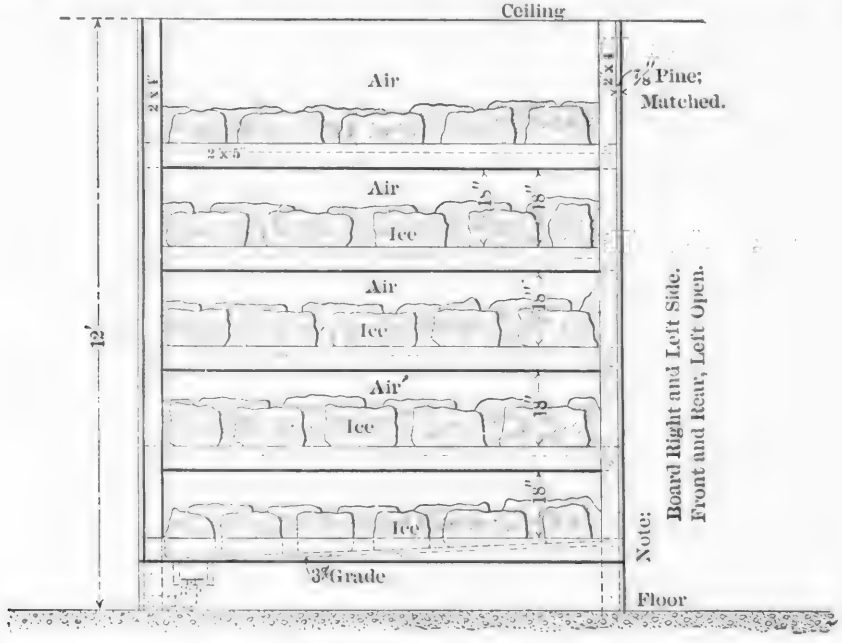
This Paper, Read at a Former Meeting of The American Society of Heating and Ventilating Engineers, Is Presented in Connection with the Discussion of Air Washing at the Heating Engineers' Recent Meeting in Milwaukee

Two days previous to the commencement exercises in the Scranton High School, June, 1901, the writer was requested by the Board of Directors to devise some means by which the auditorium could be kept at a comfortable temperature during the exercises and not become overheated. Time being short, the only resource left was by the use of ice.

A rack was constructed in the fresh air inlet large enough to hold about 8 tons of ice, with several shelves having slatted bottoms, the frame being made from 2 x 6 inch hemlock studs. At 6 o'clock in the evening the ice was placed in the rack and staggered in such a way that the air was compelled to pass around and between the cakes of ice until discharged by the fan through the flues into the auditorium above, to mingle with the sultry atmosphere; tempering, diffusing and maintaining a temperature that was most invigorating.

The bottom or floor of the rack was made from matched pine lumber and lined with No. 28 galvanized iron, and drained by a 2-inch gas pipe.

Two fans of the disk type are employed to ventilate this building, one 11 feet diameter, and an 8-foot diameter exhaust fan, located in the attic, the air being forced into the auditorium through a vertical flue at each side of the stage and from above the dressing rooms, foul air making its exit through the registers in the floor, and which are located in the aisles. The construction of this system admits of by-passing all the air intended for the building through the auditorium.



Front Elevation

REFRIGERATOR FOR HIGH SCHOOL.

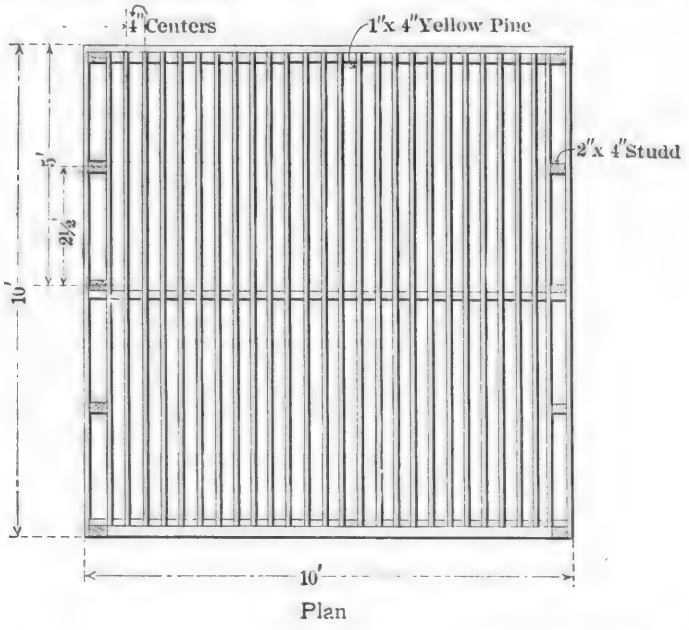
That such an arrangement is necessary can readily be seen from the fact that the seating capacity of this room is 900, but on occasions of this kind about 1,400 persons gain admittance, filling every available space to overflowing.

The outside temperature was 90° F., while the inside temperature was maintained at 76° F. The humidity was normal, and at no time reached a point of saturation. That it proved satisfactory can best be demonstrated by the fact that the directors were so well pleased that they desire the method to be used for the coming exercises, June, 1902.

The size of the auditorium is 80 feet by 80 feet by 20 feet high. The amount of ice melted was, on June 11, 13,600 pounds; June 12, 11,800 pounds; June 13, 13,000 pounds, making a total of 38,400 pounds melted during the three nights. The fans were designed to deliver 3,000,000 of cubic feet of air per hour under the friction of the ducts; the speed of the plenum fan was 100 revolutions per minute and that of the exhaust fan 120 revolutions per minute. By the use of calcium chloride an absolute control of the moisture was maintained.

In the case of rooms cooled by means of ice, or by direct ammonia expansion, or by any refrigerating plant, calcium chloride permits of an easy regulation of the percentage of moisture, as it has a capacity to absorb three times its own weight in moisture before becoming fully dissolved.

The method of applying calcium chloride for this purpose is to dispose the same in shallow pans with perforated false bottoms, so as to allow the accumulated moisture to drain off and deposit in the bottom of the pans, and they should be placed in the ducts where the rapid currents of air pass over the surface of the calcium. The commercial calcium chloride should be practically chemically pure, containing no chloride of sodium or chloride of magnesium, which, with the above purpose in view, are absolutely useless, having comparatively little affinity for moisture.



Plan

Industrial Ventilation

In a recent article by Miss Gertrude Beeks, Welfare Secretary of the National Civic Federation, the subject of Industrial Ventilation is thus presented:

Systems of ventilation which permit a complete change of air in the workrooms at least every fifteen minutes are already installed in many modern structures. Employers are beginning to realize the desirability of going to the expense of installing such systems in old buildings. In one notable case the cost of installation was six thousand dollars, but the reduction thereafter of the percentage of absences because of illness was so great that the employer was compensated for the outlay. He also found that while previously the employees were likely to become stupid the latter part of the afternoon, the new system maintained alertness during the entire day.

Relative Economy of Steam and Gas Power When Exhaust Steam Is Used for Heating*

By F. W. Ballard

The present time, when the gas engine is becoming so popular, is a good one to make a comparison between the cost of power generated by the gas engine and the cost of power from steam, when conditions are such that either the heating of buildings or the carrying on of some of the processes of manufacture can be accomplished by the use of exhaust steam from the steam engine.

It is generally conceded that when the power alone can be used, and the waste heat from the steam engine and gas engine is not utilized, the gas engine is the more economical power producer. This is no doubt true under the usual conditions, for the gas engine has the advantage of being the most economical prime mover we have as far as fuel consumption is concerned. It has also been shown that in a modern, well-designed gas-engine plant the cost of maintenance need not be more than half what the cost of repairs would be in a steam-power plant of the same capacity; the cost of labor also would probably not run much over half what the service account would total in the steam plant.

COST OF FUEL

However, it is not always possible to use as cheap fuel in the gas engine as can be found available for consumption under the boilers of the steam plant. We can use the cheapest grades of coal to advantage for the generation of steam; but we must manufacture gas for the gas engine, if natural gas is not available; and while the best result we can get with the highest type of steam plant is 1 horse power hour for about 20,000 heat units, we can get the same power from the ordinary gas engine with the consumption of only 9,000 or 10,000 heat units. Yet this vast difference in economy may easily be offset by the difference between the cost of the coal and the gas.

Twenty cents per 1,000 is about the lowest limit we can reach in the manufacture of blue water gas, and 30 cents per 1,000 is the price which must be paid for natural gas at nearly every place to which it has been piped in this state; and these prices, namely, 20 cents for artificial and 30 for natural gas, are not far from the same value per heat unit, natural gas having a thermal value of about 1,000 B. T. U. per cubic foot, and coal gas about 650.

If 1 brake horse power hour can be produced by the gas engine with 10,000 B. T. U., as we have just stated, this would mean a consumption of about 10 cubic feet of natural gas, which would represent a cost for fuel of about 0.3 cent. Assuming a cost of coal of $1.50 per ton, which is a fair average for the grades used in the general run of power plants, and a thermal value of 14,000 B. T. U. per pound, we find in the steam plant mentioned above, which is generating 1 horse power hour on 20,000 heat units, that the cost of fuel will amount to about 0.1 cent per horse power hour. Thus, under the conditions which are most generally found in a great majority of power plants in this state, the cost of fuel in a steam plant would be less than the cost of fuel in a gas-engine plant of the same capacity.

COMPARISON FOR STEAM AND GAS-ENGINE PLANTS

The above figures are to a large extent theoretical, and would no doubt be difficult to realize in both the steam and gas-engine plant under the practical conditions of continuous operation. In this connection, some information given by Mr. J. R. Bibbins in a paper read before the American Institute of Electrical Engineers in December, 1903, is particularly valuable, as it consists of records of results obtained from the operation of a number of electric light and power plants using gas engines as their principal motive power. The records extend

*From a paper read at the Fifteenth Annual Meeting of the Ohio Society of Mechanical, Electrical and Stationary Engineers.

over a long period, and give a fair average of the cost of power in the station.

It is interesting to note that in 11 of the plants described in this paper, the records on the operating costs of which covered a period of from 4 to 9 months, the cost of gas at the engines, which consisted principally of artificial gas manufactured from coal, averaged 33.9 cents per 1,000 cubic feet; and the cost for gas averaged 1.4 cents per kw. hour.

Two of the plants described in the paper referred to are particularly valuable for our purpose, as they furnish data upon the comparative economy of gas-engine and steam-engine plants. In this instance two independent stations were operated, one with steam engines and the other with gas engines run in connection with a gas works. The cost of fuel in the steam plant was 1.38 cents per kw. hour, and in the gas plant 0.75 cent per kw. hour.

In this plant Mr. Bibbins estimated that 92,000 heat units were required per kw. hour in the steam plant, and only 29,100 heat units in the gas-engine plant. These figures represent the average results as shown by the records for a year's run. Both these plants ran from 15 to 18 hours per day, the steam plant consisting of compound condensing engines and water-tube boilers. The steam plant was of 1,250 horse power capacity, and the gas-engine plant of 685 horse power. Another plant described in this paper, having about 800 horse power capacity and operated, during the period covered by the records, first by steam engines and afterward by gas engines, showed the following results: The total fixed charges on the steam plant, including interest on the investment, depreciation on buildings and machinery, taxes, insurance, etc., amounted to $22.30 per brake horse power per year. The net operating cost was $36.40, making a total cost of $58.70. In the gas-engine plant the fixed charges amounted to $15.20 per brake horse power per year, and the net operating cost was $14.80, making a total cost for power in the gas plant of $30.50 per horse power per year.

These figures are certainly favorable to the gas-engine plant as far as the cost of operation is concerned, and I believe that it is generally conceded that where it is not necessary to use exhaust steam for heating, and where reliability in the way of continuous operation is not necessary, the gas engine has the advantage.

EXHAUST STEAM FOR HEATING

However, the feature which gives the steam plant a decided advantage over the gas plant in the way of economy is the possibility of using the exhaust steam from the engine for heating. Of course, this precludes the use of condensing apparatus in connection with the engine, and consequently lowers the economy of the steam plant considerably; but since the latent heat contained in the exhaust steam amounts to about 80 per cent. of the total heat of the steam before going to the engine, the lowering of the efficiency incident to running the engine non-condensing becomes of minor importance. In fact, it would be more proper for us to consider the power generated from the steam before it goes to the heating system as a by-product of our steam heating plant.

Of course, there are a great many plants in operation at the present time where it is not possible to make use of the exhaust steam, but by far the great majority are situated ideally for profiting in this way. All power plants in large office buildings, for instance, come under this class; and most manufacturing companies have buildings to be heated which will utilize most, if not all, of their exhaust steam. In addition to the heating of buildings, a great many of the manufacturing concerns can make use of the heat of the exhaust steam for carrying on certain processes necessary in their work, thus saving the use of live steam.

LIVE STEAM, WITH EXHAUST

Even in cases where the temperature necessary is higher than that of steam at atmospheric pressure, it is not only possible but perfectly feasible to use the exhaust steam for bringng the temperature up to a certain point, and then to supplement by the use of live

steam, thus making a great saving on what might otherwise be a very expensive operation.

In the dry color works of the Chicago plant of the Sherwin-Williams Company we have some good opportunities to make use of this principle. In some of the processes it is necessary for water in large quantities to be brought to the boiling plant. This we have arranged to accomplish by drawing the water from a tank through which pass coils of pipe in connection with the exhaust steam heating system. If capacities are properly figured, the temperature of the water on leaving these tanks is close to 200° F., and it is only necessary to increase it from 12° to 15° by the use of live steam. If we assume that the average temperature of the cold water was 60° F., which is probably about correct, as the water being supplied from artesian wells, the amount of live steam necessary to bring the water to the boiling point is only about 10 per cent. of what it would be were it heated entirely by the use of live steam.

HEATING BUILDINGS

The use of exhaust steam for heating buildings has come to be such a familiar thing with a great many engineers that they look upon it as a natural function of the steam power plant; and yet, in figuring costs, it is very seldom taken into consideration.

In a paper presented by the writer at the Toledo meeting of this society in May, 1905, a system of power plant accounting was described in which a method is used for determining the amount to be charged against departments and buildings for heating by exhaust steam, together with the consequent credit to be made to the power plant for this service. It is, of course, necessary, in order to arrive at the correct cost of steam power, to make the proper charges for any and all uses to which either live or exhaust steam may be put, and the corresponding credits back to the power plant give us the net cost of power.

CHARGE FOR HEATING

The charge which we make to the different buildings and departments for the use of exhaust steam for heating is at the rate of 2 cents per month per square foot of radiating surface for 6 months in the year. The charge for live steam which it is necessary to use for various purposes is generally determined by taking the amount of condensation for a certain period of time or for a certain operation, and then estimating the proportion of the total steam generated in the power plant which is being used in that department, and making a charge to the department each month for that proportion of the total cost of operating the boiler room. This amount includes the cost of coal delivered at the boiler, boiler room service, boiler room maintenance, insurance, supervision and administration charges, removing ashes, etc.

STEAM REQUIRED

I find in practice that, on an average, when a full head of exhaust steam is maintained upon the radiators, about 250 heat units are radiated per hour per square foot of radiation. This amount is approximately correct as per Carpenter's tables, when the difference between the temperature of the radiator and the air in the room is 150° F. According to the same authority, the amount of steam condensed per hour per square foot of radiation would be about 0.25 pound, or, in other words, 1 pound of steam would supply 4 square feet of radiation.

I find in practice, however, that in using exhaust steam 1 pound will supply only about 3 square feet of radiation. Assuming this amount to be correct, and that the engines in the power plant will consume 30 pounds of steam per horse power hour, then 1 horse power capacity in the power plant would furnish exhaust steam enough to heat 450 square feet of offices, 600 square feet in the factory, and 900 square feet in the warehouse.

FUEL REQUIRED AND COST

If we figure that 1 pound of coal will produce 8 pounds of steam, it will supply exhaust steam to about 25 square feet of radiating surface for 1 hour, and if coal costs $2 a ton, the fuel necessary to supply 1 square foot

of radiation for 1 month, making proper allowance for the value of the steam used in the engine, will cost about 1 cent, assuming that we supply steam to the radiator for only about 10 or 12 hours per day.

Also, assuming that the amount of boiler room expenses will just about equal the fuel cost, we are justified in estimating our cost for exhaust steam at 2 cents per square foot per month during the months when heating is necessary. I do not believe that very many heating plants can be operated for heating alone, and supply live steam for this purpose, and get under a cost of 2 cents per square foot per month.

After making the proper credit to the total cost of power generation for live and exhaust steam as outlined above, we have been able, in some of our plants, to produce electrical power at the switchboard for 1.5 cents per kw. hour. This, I believe, is better than can be done in any plant of the size we are operating by using gas engines, and particularly so when it is taken into consideration that, if we used gas engines for power, it would be necessary to operate a boiler plant to generate steam for heating and for the many other purposes to which we put it.

USE OF COMPOUND ENGINES

There are great possibilities along the line of using high-pressure compound engines for power which can be operated either condensing or non-condensing, so that they can be run condensing in the summer time, or whenever the exhaust steam is not needed for heating, and operated non-condensing the balance of the time.

We recently installed a 300-horse power Westinghouse compound engine in our Newark factory, to be run on 150 pounds steam pressure, non-condensing. This is now operating on an average of about 23 pounds of steam per horse power hour. The idea in this is all right as far as it goes, but I consider that a later installation which we have just made, of a 300-horse power compound engine in our Chicago factory, which can be run non-condensing when we need exhaust steam and condensing when we do not need the steam, is a step still further in advance.

HEATING FROM GAS ENGINES

So far, we have given no credit to the gas engine for the possibility of using the heat of the exhaust gases for heating buildings. That there is such a possibility cannot be denied, but it is limited because, first, of the low fuel consumption of the gas engine per horse power hour, and, second, the large percentage of the heat units contained in the fuel which are converted into power. In a simple non-condensing steam engine using 30 pounds of steam there are about 30,000 heat units contained in the exhaust steam for each horse power hour, and this would supply about 90 square feet of radiation after due allowance for losses in the supply pipes, steam for heating feed water, etc., had been deducted.

The waste heat in exhaust gases from the average gas engine would contain about 6,000 heat units per horse power hour, which would be available for use in heating, and would supply only about 20 square feet of radiation, after due allowance for losses. About half of this heat would be contained in the jacket water, and probably the easiest way to utilize the total heat available would be to put the exhaust gases through a tubular heater and combine the jacket water with the water from this heater in a hot-water heating system. I have seen accounts of a number of gas-engine plants where hot jacket water has been used for heating, and I believe that there are a few instances where the heat of exhaust gases has been still further utilized by heaters as outlined above; but the possibilities of any extensive heating systems being installed along these lines are no doubt limited.

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, until 3 P. M., October 1, 1907, for the construction (including plumbing, gas piping, heating apparatus, electric conduits and wiring) of the U. S. Court House and Post Office at Eau Claire, Wis.

NEW DEVICES

A Pipe Covering that Prevents Electrolysis

In municipalities where the street car lines are operated by the trolley system, there is more or less destructive action upon underground pipes by electrolysis —an insidious, latent form of electrical disintegration that if often overlooked because its operations are confined to pipes that are buried underground, where it is hard to detect.

This destruction is caused by the "ground return" current flowing through any pipes in its path, and consists of pitting or corrosion of the pipe at the point where the current leaves it. The pipes most affected by electrolytic action are lead and wrought iron. As a result, all lead water pipes and lead covered cables, as well as wrought iron gas and water service and distribution pipes, when placed underground, are subject to this destructive influence.

A pipe covering known as Electroless is the outgrowth of the demand for a preventive of electrolysis in underground pipes. It is a sectional covering of a specially prepared asbestos paper in laminated form, impregnated, and coated with a water-proof insulating compound, which presents a barrier to the transmission of electric current. Electroless pipe covering acts as an insulating medium between the pipe and ground, and, being made of indestructible materials, is durable and has a lasting efficiency.

PIPE COVERING TO PROTECT PIPES FROM ELECTROLYSIS

This pipe covering is ¼ to ⅜ inch thick, and is made in 3 feet sections, to fit various sizes of iron and lead pipes. All longitudinal and abutting joints are sealed by means of strips and insulating cement, which are furnished with the covering. For sleeve couplings, etc., a special sleeve of Electroless pipe covering is provided. The manufacturers of the covering are the H. W. Johns-Manville Co., 100 William street, New York.

Trade Literature

Common Sense Heating and Sanitary Plumbing is an interesting and beautifully gotten up booklet, issued by the Pierce, Butler & Pierce Mfg. Co., Syracuse, N. Y., dealing with the subjects of hot water and steam heating, heat regulation, radiation and modern sanitary plumbing. The book is prepared for the use of the house builder as well as for the engineer, and both will find much to interest them in the reading matter which is crisp and to the point. The illustrations are worthy of special note and include sectional interior views showing typical heating installations. Each page of reading matter is printed on a background of well-drawn city and country scenes. Sizes 6 x 8¼ in. Pp. 36.

Atmospheric System of Steam Heating is illustrated and described in a circular sent us by the American District Steam Co., Lockport, N. Y. This system is based on the principle of supplying steam at practically atmospheric pressure in the form of vapor. The supply of steam is delivered to the top of the radiator which must be of the hot water type, with top and bottom connections. The return lines in the basement are open to the atmosphere. Specially constructed valves regulate the admission of steam to the radiators. "Underground Piping for Steam Distribution" is another recent publication of this company which will be found suggestive to those engaged in this character of work. The methods described of laying underground pipe are equally adapted to a vacuum, low or high pressure, one or two pipe steam or hot water system.

Empire State Engineering Co., 149 Broadway, New York, has published a new catalogue illustrating and describing the Empire State Refrigerating Machine, which has won a high reputation for this class of apparatus. Several photographic views of the refrigerating machine are shown, including the steam driven and belt driven types together with descriptions of each type. Typical installations of the Empire State refrigerating machine are included in the catalogue, a copy of which, we understand, will be mailed to those asking for one.

National Radiator Co., Johnstown, Pa., has published its new catalogue of radiators, boilers, tank heaters and specialties. Included in the catalogue, in addition to illustrations and descriptions of the company's extensive line of heating apparatus, are many tables and rules and other information useful to the heating engineer. Size, 4½ x 7 inches. Pp. 122.

Remanit, a pipe covering made of carbonized silk and sold in rope and braid forms, is described in a circular recently issued by the manufacturers, the J. Edward Ogden Co., Cedar and Washington streets, New York. The catalogue contains details regarding the application and uses of Remanit in steam and hot water heating, gas and water work and heating pipes in cars, steamboats, mines and collieries and refrigerating apparatus. There are also tests showing the efficiency of various forms of pipe covering.

Vanda Sheet Packing, for engine rooms, Transite Asbestos Linings for Railway controllers, How to Clean a Boiler with Magic Compound and Keystone Plumbing Pipe Covering are described, with numerous views, in separate folders recently issued by the makers, the H. W. Johns-Manville Co., 100 William street, New York.

Kewanee Flange Union of brass and malleable iron, with self-seating ball joint, a recent product of the Western Tube Co., Kewanee, Ill., is featured in one of the company's recent circulars.

Spontaneous Ignition of Wood

A lamp hanging too near a beam, a steam pipe or hot air pipe laid too close to woodwork, dust settling down in thick layers on heated vessels or pipes, defective insulating materials around a steam pipe, stove, fireplace, drying plant, etc., which are thereby enabled to radiate heat continuously against wooden articles, all those possibilities may occur in any factory, and under favorable conditions often lead to very perplexing outbreaks of fire. High pressure is unnecessary. Steam under a pressure of 5 atmospheres, equivalent to a temperature of 250° to 300°, being sufficient, the only essential being prolonged action. The same also applies to any hanging lamp. If the action is suspended for some time and the heat comes into play only at intervals this does not eliminate the danger, but merely delays its occurrence for the time being.

The phenomenon of spontaneous ignition proceeds in the following manner: Heat when sufficiently prolonged renders organic matter like wood porous, whereby the wood is enabled to manifest the tendency possessed by all porous substances—namely, to absorb and attract gases. Now the only gas available under the circumstances is air, but a selective affinity is exerted on the two constituents of air, the oxygen being occluded more readily than the nitrogen, so that the porous wood becomes charged with air in which oxygen predominates. Dried wood is also able to take up a large quantity of gas, about 30-90 times its own volume, and as soon as the action of heat recommences the by no small accumulation of oxygen in the pores greatly favors the production of pyrophoric carbon. When this alteration of heating and gas absorption is continued for some time a temperature of 515° is no longer essential to the production of pyrophorous carbon, 300° being sufficient under these circumstances, and in the presence of occluded oxygen the carbon quickly takes fire.

"The Art of Cutting Metals," by Frederick W. Taylor, M.E., Sc.D., which was the presidential address presented at the last annual meeting of The American Society of Mechanical Enginers, has been reprinted and bound in cloth by the society, price $3.00. This or any other publication of the society may be had by addressing the secretary, 29 West 39th street, New York. It is not necessary to send orders through members. None of the publications of The American Society of Mechanical Engineers is copyrighted.

A Course in Steam Engineering, approved by the New York branches of the National Association of Stationary Engineers, will be inaugurated at the Twenty-third street branch of the Y. M. C. A., 215 West 23d street, New York, commencing in October, 1907, and running to June, 1908. The classes will meet evenings. The course of instruction will be under the direction of Mr. Wilson Van Buren, editor of the Engineer's List, who successfully conducted a similar course last year. Further information regarding this course may be had by addressing Mr. Burt B. Farnsworth, 215 West 23d street, New York.

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, until 3 P. M., September 30, 1907, for the construction (including plumbing, gas piping, heating apparatus, electric conduits and wiring) of the U. S. Post Office at Selma, Ala.

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, until 3 P. M., September 24, 1907, for the construction (including plumbing, gas piping, heating apparatus, electric conduits and wiring) of the U. S. Post Office building at Hamilton, Ohio.

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, until 3 P. M., October 7, 1907, and then opened for the construction and mechanical equipment (except plumbing) of an extension to the U. S. Post Office, Court House, etc., at Baltimore, Md.

TRADE AND MISCELLANEOUS NOTES

Deaths

Homer Parmelee, inventor of the Parmelee pipe wrench, and for many years a pattern maker with Bartlett, Hayward & Co., Baltimore, Md., died in Chicago, August 12th, in his 89th year. He was a son of Sidney Parmelee, of West Troy, N. Y., the inventor of the first successful coal or wood cook stove, known as Parmelee's Diamond Cook Stove.

Albert F. Hall, for many years with the George F. Blake Mfg. Co., Cambridge, Mass., and its successor, the International Steam Pump Co., died in Somerville, Mass., July 22d, in his 62d year.

Harry A. McQuade, president of the McQuade Plumbing Co., Chattanooga, Tenn., died July 25th. He was 60 years old.

Patrick Hanley, father of Frank S. Hanley, of New York, secretary of the national committee of the Confederated Supply Association, died at his home in Oswego, N. Y., August 12th.

Miscellaneous Notes

Joplin, Mo.—The measure granting Charles U. Porter the right to construct and operate a heating and power plant in Joplin was killed at a meeting of the city council.

Carroll, Neb.—George H. Long, representing the Michigan bondholders, bid in the plant of the Carroll Heat, Light and Power Co., at Carroll, at $71,000.

St. Paul, Minn.—The proposition to grant a franchise to the Minneapolis Heating and Transmission Co. to construct and operate a subway in the streets of Minneapolis was voted down at a recent meeting of the subway committee. The main provisions of the franchise were published in the August issue of THE HEATING AND VENTILATING MAGAZINE.

Seattle, Wash.—A franchise for a central heating plant has been granted to the Seattle-Tacoma Power Co., extending the life of the present franchise until 1934.

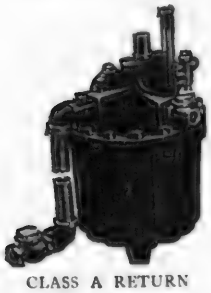
G. H. Gray, Escanaba, Mich., who has been engineer for the Escanaba Mfg. Co., has been appointed superintendent of the heating plants in all of the public schools in that place.

Toledo, Ohio.—Homer T. Yaryan has been given a franchise for a heating and lighting system in Toledo.

Niagara Radiator Company creditors met at Lockport, N. Y., August 31, to consider the advisability of authorizing the trustee to sell at private sale the property of the company.

Thomas E. Crone, late manager of sales for the International Heater Co., Utica, N. Y., has organized the Atlantic Supply Co., commission jobbers, at 1123 Broadway, New York. The company will deal in heating supplies.

American Radiator Co., at a meeting of its directors in Detroit, Mich., declared a dividend of 1¾ per cent. for the quarter on the preferred stock, payable August 15th to stockholders of record August 8th. A dividend of 1 per cent. was declared on the common stock, payable September 30 to stockholders of record September 21st.



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ESTABLISHED 1870

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Manufacturers' Notes

Portland General Electric Co., Portland, Ore., will build a central steam heating plant at Portland at a cost of $200,000, to supply heat to buildings in that city.

A. J. Lindemann & Hoverson Co., Milwaukee, Wis., has increased its capital stock from $400,000 to $500,000.

J. L. Mott Iron Works, New York, has opened a branch office in Pittsburg in the Machesney Building.

D. T. Williams Valve Co., Cincinnati, Ohio, were among the sufferers in a fire which destroyed a large manufacturing district at Hunt street and Reading road. The company's old quarters on Sycamore street were destroyed, containing the machinery for the manufacture of grease and oil cups.

Lucas Pump Co., Dayton, Ohio, has succeeded to the pump business of the C. O. Lucas Co. The management of the business remain the same.

Plumbers' and Steamfitters' Supply Co., Buffalo, N. Y., has moved to larger quarters at 106-108 Pearl street.

Dighton Furnace Company's plant at Taunton, Mass., was destroyed by fire, the loss being estimated at $60,000.

Cunningham Iron Co., Boston Mass., reports the loss by fire of its boiler plant on August 2. The damage will amount to $100,000.

General Fire Extinguisher Co. has acquired the business of the A. Carpenter & Sons Foundry Co., Providence, R. I. Henry A. Carpenter, formerly president and treasurer of the foundry company, will continue to run the business as the Providence Foundry Department of fire extinguisher company.

United States Heater Co., Detroit, Mich., has appointed A. G. Pittelkon as manager of its Omaha branch office. John C. Read, the former manager, has been transferred to the East.

New Incorporations

Central Heating and Mfg. Co. Little Rock, Ark. Capital stock, $200,000. President, George Caldwell; directors, Charles T. Caldwell, T. V. Wilson, W. M. Kavanaugh and J. M. Spradling. The objects of the company are to furnish water, steam and electricity for domestic heat or power. The incorporation of this company is the result of the sale of the Little Rock Heating Company's plant to George W. Caldwell.

John Boyd Plumbing and Heating Co., New York. Capital, $5,000. Incorporators: Frank Paulding, William J. Crow and Robert H. Murray.

Justus Plumbing and Heating Co., Massilon, Ohio. Capital, $10,000. Incorporators: F. W. Justus, E. W. Bulloch, Daniel H. Kurtz, W. H. Crawford and William J. Hollander.

Findlayson Heater Co., Detroit, Mich. Capital stock, $50,000. Among those interested are Alexander W. Findlayson, Charles H. Bloom and Daniel C. Barber.

Northern Water Softener Co., Portland, Me. Capital, $30,000. Incorporators: W. W. Baldwin and C. D. Fullerton.

Keilly Heater and Evaporator Co., Jersey City, N. J., capital $100,000, to manufacture feed water heaters, evaporators and condensers. Incorporators: George R. Warnew, Samuel B. Howard and John R. Turner.

Vilter Mfg. Co., Milwaukee, Wis., capital $60,000, to manufacture engines and machinery.

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New Idea Hot Water Heating Co., Paterson, N. J., capital $200,000, to manufacture hot water and steam boilers. Incorporators: Edward D. Cronin, of Brooklyn, and Fred Knowlton and Edgar A. Montfort, of New York.

Dixon Wrench Co., New York, capital $25,000, to manufacture pipe wrenches. Incorporators: C. D. Cronin, of Brooklyn, and E. A. Montfort and Fred Knowlton, of New York.

Swedish-American Radiator Co., Eskildstuna, Sweden. Capital 2,000,000 kronor ($50,000).

Aelsop Heating Co., Brooklyn, N. Y. Capital, $3,000.

Stone Bros. Co., Detroit, Mich, capital $20,000, to conduct a heating and plumbing business. Incorporators: William G. Stone, Charles H. Junth and Nicholas Schwenker.

Krohn Hardware Co., Whitewater, Wis., capital $10,000, to conduct a hardware, heating and plumbing business.

Winslow Plumbing and Heating Co., Cleveland, Ohio. Capital, $10,000. Incorporators: R. E. McKisson, E. Wedsworth, S. J. Wallace, M. E. Foster and C. T. Austin.

United Expansion Bolt Co., Ltd., Brooklyn, N. Y. Capital, $30,000. Incorporators: George B. Martin, of Brooklyn; William A. Copper, of Jersey City, and E. J. Mastaglin, of Brooklyn.

Hess, Churchill & Marlow, New York, incorporated to manufacture engines and machinery. Incorporators: Warren C. King, of Bound Brook, N. J.; William M. Clark, of New York, and Thomas P. Carty, of Plainfield, N. J.

Acme Furnace Equipment Co., New York, capital $100,000, to manufacture boilers and machinery. Incorporators: J. M. Howarth, E. Hirschberg and L. C. Ferguson, all of New York.

Sullivan & Worthington Co., Buffalo, N. Y., capital $15,000, to conduct a heating business. Incorporators: J. A. Sullivan, George D. Worthington and Fred G. Bagley, all of Buffalo.

Vanderman Bros. Co., Hartford, Conn., capital $2,000, to conduct a heating and plumbing business. Incorporators: W. F. Vanderman, C. A. Vanderman and Edward L. B. Vanderman.

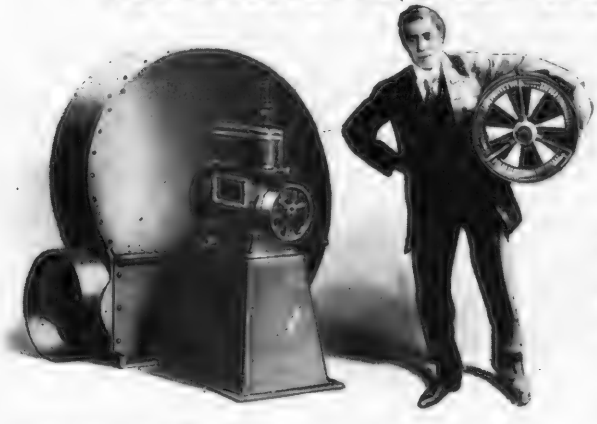
Billings Mutual Heating Co., Billings, Mont., capital $100,000, to establish a central heating plant in Billings. Incorporators: P. B. Moss, A. B. La Mott, Austin North, John D. Losekamp, R. D. Stocking and Frank H. Beeman.

Hyatt-Wise Mfg. Co., Columbus, Ohio, capital $25,000, to manufacture dies, tools, gas burners, sheet metal specialties, etc.

Barnes-Stephens Plumbing and Heating Co., Colorado Springs, Colo. Capital, $5,000.

Moore Complete Combustion Furnace

WING'S TURBINE FAN SYSTEM OF MECHANICAL DRAFT



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Designers and Builders of Heating and Ventilating Systems

Co., Bethel, N. H., capital $500,000, to manufacture steam and hot water heaters and hot air furnaces. President, Hugh K. Moore; treasurer, Joseph Guay, both of Berlin, N. H.

Tunnel Ventilating Co., New York, capital $100,000, to manufacture apparatus for ventilating tunnels, subways, etc. Incorporators: Alexander Miller and Gordon Miller, of New York, and Charles A. Morris, of Bloomfield, N. J.

Rolf-Martin Co., St. Louis, Mo., incorporated to manufacture water heaters and heating apparatus. The company's main office will be at Fort Wayne, Ind. Incorporators: Herman Rolf and Emmett Martin. Mr. Martin is the inventor of the Martin back water trap.

Chard-Ratz Plumbing Co., St. Louis, Mo. Capital stock, $2,000.

Middlesboro Plumbing and Heating Co., Middlesboro, Ky. Capital stock, $3,000.

Strand Heater Co., Cleveland, Ohio, capital $10,000, to manufacture a new gas heater. Incorporators: Henry Strand, John Freund, J. G. Reyant, L. D. Greenfield and A. M. Freund.

Bixby-Krelle Co., Omaha, Neb., capital $15,000, to conduct a heating and plumbing business. Incorporators: J. C. Bixby, George Krelle and Ray W. Bixby.

Advance Radiator Co., Syracuse, Ind., capital $60,000, to manufacture boilers, radiators, etc. President, Timothy Holland; secretary, Charles B. Bentley; treasurer, Silas L. Kettig; superintendent, Carey Wright. The company has taken over the plant of the Reynolds Heater Co., at Warsaw, Ind., where the business will be conducted until the completion of the new plant at Syracuse.

Kunze & Manuel Heating and Ventilating Co., Omaha, Neb. The firm will continue the sale of the Manuel-Smith system of heating.

Philadelphia Drop Forge Co., Philadelphia, Pa., capital $25,000, to manufacture drop forgings.

Zenith Mfg. Co., Duluth, Minn., capital $50,000, to manufacture steam flue cleaners and steam boiler appliances.

Foster Plumbing Co., Seattle, Wash. Capital, $10,000. Incorporators: Samuel C. Foster, George Foster and A. C. Smith.

Hygiene Heating Co., Philadelphia, Pa. Incorporators: L. S. Barton, V. S. DeVoll and Andrew C. Edgar.

Acme Asbestos Covering and Supply Co., Chicago, Ill., capital $10,000, to manufacture pipe and boiler coverings. Incorporators: Herbert A. Bell, Alfred E. Hernes and K. A. Paine.

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Perco Regulator Co., New York, capital $30,000, to manufacture combustion devices. Incorporators: William W. Chadbourne, Charles E. Otis and J. Robert Rabin, all of New York.

Multicoil Heater and Evaporator Co., Jersey City, N. J., capital $100,000, to manufacture feed water heaters, etc. Incorporators: Sidney A. Anderson, L. H. Gunther and Samuel B. Howard, all of Jersey City, N. J.

Store Heat Mfg. Co., Los Angeles, Cal. Capital, $150,000. Directors: Albert Carter and N. W. Kellaway.

F. Holtz Co., Evansville, Ind., capital $35,000, to manufacture steam pumps and machinery.

Holyoke Supply Co., Holyoke, Mass., capital $10,000, to conduct a heating and plumbing business. President, Daniel F. Moriarty; secretary and treasurer, Louis D. White, of Springfield.

New Firms

Schneider-Scharff Co., Utica, N. Y., is a new heating firm of heating contractors composed of Paul W. Schneider and Lewis J. Scharff.

Bartley-Kennedy Co., 6101 Center avenue, Pittsburg, Pa.—Mr. F. C. Bartley, of the new firm, was formerly superintendent of the John T. Bealor Mfg. Co.

Coe & Coleman Co., New Haven, Conn., is a new firm of heating and plumbing contractors. President, Clinton E. Coe; treasurer, Frank L. Coleman; secretary, Frederick L. Perry.

Bolton Plumbing Co., Webb City, Mo., is the title of a new heating and plumbing firm located at 209 East Dougherty street in that place.

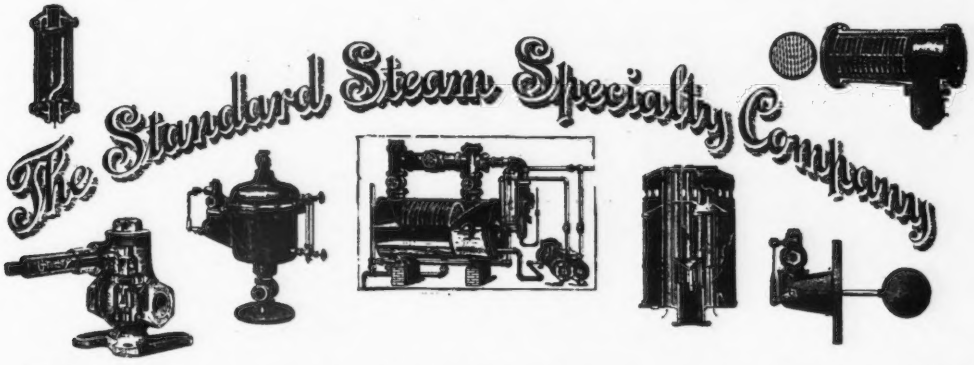
Oswego Sanitary Plumbing Co., Oswego, N. Y., heating and plumbing contractors. Vice-president, Frank D. Donovan; secretary, C. W. Dings.

Flowers Co., East Pittsburg, Pa., which discontinued business a year ago, will resume as heating and plumbing contractors. Mr. John Flowers, who gave up the business to accompany his wife to Florida on account of her failing health, has returned to East Pittsburg, his wife having died of her illness.

Business Chances

Lansing, Mich.—The city hall will be equipped with a direct steam heating system, to cost $3,100.

Grand Rapids, Mich.—A heating plant for the new contagious disease hospital, to cost $6,000, was recommended by the ways and means committee to the common council and was adopted by the council.



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Bushnell, Ill.—The heating plant in the county jail at Macomb has been condemned and will be replaced by a new plant.

Business Changes

L. W. Kamp Co., Mount Carmel, Ill., has taken over the heating and plumbing business of the Manly-Struly Company, at that place.

F. M. Wisely Plumbing Co., Marshall, Ill., has been discontinued.

R. P. Willis Plumbing Co., Springfield, Ohio, has increased its capital stock from $20,000 to $50,000.

Brown & Ferris, heating and plumbing contractors at Fayette City, Pa., has been dissolved. Mr. Ferris will continue the business at the same address.

Sniveley Plumbing Co., East Liberty, Pa., had its plant almost completely destroyed by fire, the loss being estimated at $12,000. The company has secured temporary quarters.

James N. Healy, Indianapolis, Ind., has purchased his partner's interest in the heating and plumbing firm of Healy & O'Brien.

Klatt & Baewald, Milwaukee, Wis., has succeeded to the business of C. H. Klatt, at 749 National avenue.

Newberg & Buckstrom Plumbing and Heating Co., Lincoln, Neb., is the new name of the Harris Plumbing and Heating Co., of that place.

Contracts Awarded

Lewis & Kitchen, Kansas City, Mo., steam heating plant for high school and Foster Building, to cost $3,094; also heating and ventilating Lane street school in North Topeka for $3,399.

E. C. Long Mfg. Co., Hannibal, Mo., steam heating business block on North Main street., Hannibal, for Charles S. Brothers.

Nord & Hird, Aurora, Ill., heating Bethlehem Church parsonage at St. Charles, Ill.

Crookston Plumbing and Heating Co., Crookston, Minn., heating and plumbing dormitory of the State Agricultural School at Crookston. The bid for the heating was $3,032 and for the plumbing, $2,525.

Phoenix Heating and Sprinkling Co., Grand Rapids, Mich., heating plant for the Central School buildings. The work will cost $2,910.

Thomas H. Glavin, Escanaba, Mich., heating system for the school building at Nadeau.

L. H. Prentice Co., Chicago, Ill., remodeling of steam heating plant at the Northern Illinois Insane Hospital at Elgin. The work will cost $27,000 and will include two new boilers, four mechanical stokers, a charging platform, renewal of steam pipes and installation of a vacuum system of heating.

William T. Fowden, Chester, Pa., heating plant for the Graham School.

Peninsula Plumbing and Heating Co., Calumet, Mich., steam heating plant at the Mandan to supply residence, school and large boarding house. This firm also has the contract for heating the new Croatian Co-operative Store at Red Jacket.

George W. Whitehill, Butler, Pa., steam heating and plumbing Hotel Clinton at Butler.

West Virginia Plumbing and Heating Co., Charleston, W. Va., Webster heating system and plumbing system for the Sheltering Arms Hospital in Charleston.

Alexander Ralmer, Oakmont, Pa., heating, plumbing and gas fitting in McCurdy Building. The contract amounts to $15,000.

Robert Raitz & Co., Toledo, Ohio,

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heating and plumbing clubhouse of the Toledo Yacht Club.

Staniland & Schneble, Dayton, Ohio, heating and plumbing new Roman Catholic Church at Dayton.

McClure & Co., Wooster, Ohio, steam heating and ventilating Wooster High School building.

Brohl & Apple, Sandusky, Ohio, heating and ventilating new school building in Sandusky.

Hilburn & Faulkner, Bucyrus, Ohio, heating and plumbing in new $19,000 school building at that place.

Savannah Blow Pipe Co., Savannah, Ga., has been given a contract, amounting to $10,000, for a blow pipe and heating and ventilating system for the new shops of the Central of Georgia Railway Company at Savannah. This firm will also supply the blower and piping for ventilating the new shops of the Atlantic Coast Line Railroad at Waycross.

Frank S. Spencer, Minneapolis, Minn., steam heating new school building at Chisholm.

G. H. Sutherland Co., Walla Walla, Wash., heating new recitation building of the State Institution in Pullman.

Stevenson Bros., Schenectady, N. Y., heating and plumbing Craig and Mason streets schools and Old Ladies' Home on Union street.

John F. Leary, Little Falls, N. Y., heating and plumbing new post-office building for $6,000.

Oswego Sanitary Plumbing and Heating Co., Oswego, N. Y., heating and plumbing the Carrier Flats at East Sixth and Utica streets.

Charles E. Snyder, Janesville, Wis., heating and plumbing new Third Ward School. The work will cost $2,100.

W. H. Johnson & Son Co., Indianapolis, Ind., heating and ventilating school building at Colfax for $1,683.

Cambria Plumbing and Heating Co., Johnstown, Pa., heating and plumbing Majestic Theater.

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Mouat-Squires Co., Cleveland, Ohio, hot water heating plant for O. S. Werntz's new residence on Euclid avenue.

J. W. Church & Son, Hallowell, Me., low pressure steam heating system for the high school building.

O. C. Davis Co., Racine, Wis., heating Manual Training School at Grand Rapids, Wis.

F. E. Green, Janesville, Wis., heating and plumbing new Schlitz Hotel.

Boyd & Ryan, Peoria, Ill., heating palm house at Glen Oak Park for $4,925.

H. H. Frink & Son, Carthage, N. Y., steam heating town hall.

Mewes Heater Co., What Cheer, Ia., heating new school building.

Thomas E. Gildea, Syracuse, N. Y., heating Steam Engineering Building No. 95 at the Portsmouth Navy Yard, Portsmouth, N. H. A system of forced hot water heating will be installed. The work will cost $9,000.

J. H. Renner, Alexandria, Minn., steam heating and ventilating high school building at Parker's Prairie.

Bartley-Kennedy Co., Duquesne, Pa., heating addition to the high school building.

C. M. Masters, Mankato, Minn., steam heating system for SS. Peter and Paul's Church for $1,852.

Merrill Co., Boston, Mass., heating and ventilating the Austin Biscuit Company's new building on Causeway street.

Tom Sweeney Hardware Co., Rapid City, S. D., steam heating Metallurgical Building at the School of Mines.

W. E. Buillon, Lincoln, Ill., heating, plumbing and gas fitting new residence of Fred Maurer at Chestervale.

Mooney & Co., Nashville, Tenn., heating school building at Jackson for $3,250.

F. A. Eagle, Merrill, Wis., heating county training school at his bid of $1,500.

W. R. Gale, Delta, Colo., heating courthouse for $4,397.25.

C. F. Bulwinkel Estate, Jefferson, Wis., steam heating St. John the Baptist's Church, school and parsonage for $3,996.

Ben Benson, Willmar, Minn., heating school building at Echo for $1,500.

Cody & Shea, Peoria, Ill., remodeling heating system in city hall. The work will cost $2,235.

George A. Brown Co., Milwaukee, Wis., heating office building for the Merchants' Investment Co.

Davenport Plumbing and Heating Co., Davenport, Ia., heating Arthur D. Ficke's new residence on Main street.

Francis Bros. & Jellett, Philadelphia, Pa., steam heating system and electrical appliances for addition to Lit Brothers' building at Seventh and Market streets.

Harry Hammann, Martinsburg, W. Va., heating Second and Fourth Ward school buildings.

Lindner & Brenner, Milwaukee, Wis., heating six double flat buildings, Nineteenth Ward School and two new buildings for the Pabst Brewing Co.

Sheridan & Chapman, Goshen, Ind., heating and plumbing Jefferson Building.

J. H. Ruckel & Son, Buffalo, N. Y., fan system of heating for the new hall of the Mizpah Lodge, I. O. O. F., at West Ferry and Herkimer streets.

Modern Heating Co., Wilkinsburg, Pa., heating system for new $75,000 store and apartment building for W. E. Carnahan. This firm also has the contract for installing heating systems in the two $25,000 residences being built in that city for S. A. Dickie & Co.

Doohr & Seager, Niagara Falls, N. Y., steam heating and plumbing new Temperance Hotel for $8,000.

Kewanee Sanitary Supply Co., Kewanee, Ill., heating courthouse at Cambridge for $2,100.

Fuller-Warren Co., Boston, Mass., steam heating Hodgkins School at East

30,000 HOMES
600 CHURCHES AND SCHOOLS
are being satisfactorily and economically heated by the
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